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MODELLING AND ENGINEERING ANALYSIS OF COAL FLOTATION

by

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A THESIS
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Brian C. Flintoff

Supervisor

H. A. Hamza

L. G. Plitt

Date May 10, 1985

To Patricia, Young-sook and Betty

ABSTRACT

The flotation behaviour of unoxidized coal from Gregg River Resources Limited, Hinton, Alberta, was studied in a laboratory program. Batch tests were performed in a semi-automatic flotation cell developed at the University of Alberta. The optimum flotation environment was identified with the aid of a factorial design concerned with the following seven process variables: aeration rate, collector and frother reagent dosages, conditioning time, percent solids in feed pulp, impeller speed, and pH. The main objective of the project was to produce a mathematical model of the coal flotation system which could be used for off-line optimization studies. It was not possible to derive a statistically satisfying mathematical model of the coal flotation system. The problem relates to the experimental error which is contained in the flotation rate data. Two positive findings from the modelling study were that the flotation of the Gregg River Resources coal was shown to be essentially a first-order process, and that the compound first order model was found to give the best overall fit. Of the seven factors investigated aeration rate, collector and frother additions, and percent solids in the flotation feed were judged to be important in so far as they affect flotation performance. Conditioning time, impeller speed and pulp pH were judged to be insignificant at the levels studied.

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1. INTRODUCTION

Alberta's coal reserves are well distributed throughout the province in three major geographical regions. These regions are the plains, foothills and mountains. The coals from the foothills and mountain regions are very friable, and the mining of these coals generates large quantities of material finer than 600 microns (28 mesh). As a result, fine coal cleaning circuits are needed to maximize the economic efficiency of the operation. Flotation is one of the most efficient methods of processing fine coals. The objective of flotation for western Canadian coals is to separate coal from mineral matter to meet the ash content specified by the customer. (In contrast, the objective of flotation for the Appalachian coals is to separate coal from pyrite to meet the SO_2 emissions specified by the environmental laws.)

The coal selected for this study is mined and processed by Gregg River Resources Limited, Hinton, Alberta. The mine is located in the mountain region, and its low volatile bituminous coal is primarily exported to Japan for conversion to coke. The flowsheet of the Gregg River Coal Limited preparation plant is shown in Figure 1.1.

The purpose of this study was to define, on a laboratory scale, the optimum conditions for the flotation of the fine coal from Gregg River Resources Limited. The specific objectives of this study were as follows:

a) Determine, from among those that are relatively easy to manipulate, those factors which have a significant

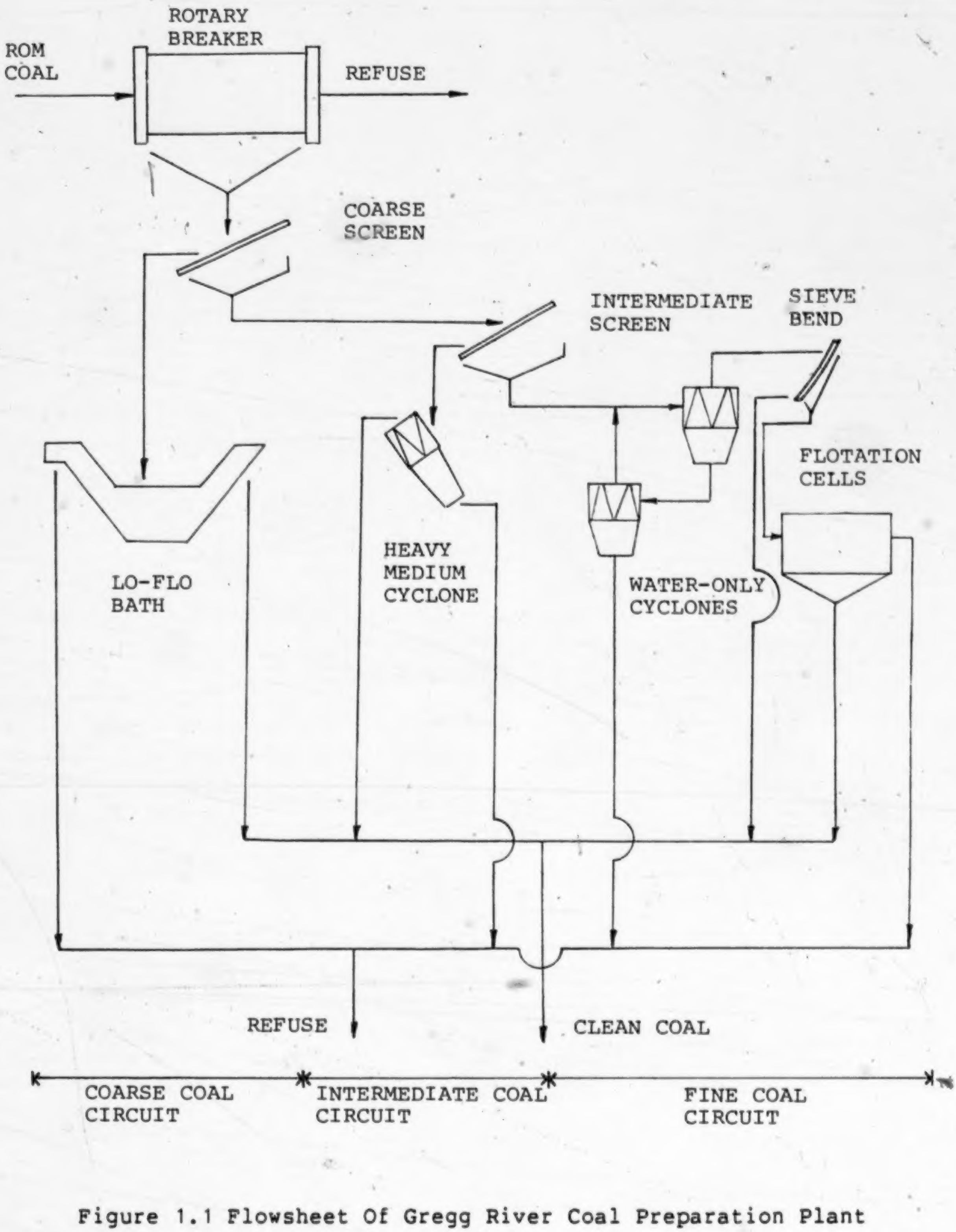

Figure 1.1 Flowsheet Of Gregg River Coal Preparation Plant

effect on flotation performance at levels encountered in typical flotation practice.

b) Using the important factors identified in (a) and, at modified levels, chosen on the basis of information obtained both from the operators as well as from (a), perform an additional set of experiments to produce a mathematical model of the flotation system. (Where possible, data from (a) was to be used in the model construction.)

c) Using the batch flotation model derived in (b) and some suitable representation of the transport character of the industrial scale flotation cell banks, perform an off-line optimization to identify the optimal plant flotation operating conditions.

Other, valuable, information which was expected to accrue through this test work included an increase in process understanding and the identification of potential process control variables.

2. THEORY AND LITERATURE SURVEY

2.1 THE FROTH FLOTATION PROCESS

A brief introduction to the flotation process is followed by a description of the factors affecting the performance and of the theory behind mathematical modeling of the coal flotation process.

2.1.1 INTRODUCTION

Since the introduction of the flotation process in early 1900's, great strides have been made in its development. This process is used in sulfide, non-sulfide metallic, industrial mineral and coal separations.

The froth flotation of coal is a physico-chemical process that depends on the selective attachment of air bubbles onto the coal particle surfaces. This process is enhanced by chemical reagents. A collector adsorbs on the surfaces of coal particles and increases the hydrophobicity of particles. The collectors are "oily" which gives them their hydrophobic character. As finely dispersed air bubbles are passed through the coal pulp, the air bubbles attach on the chemically treated surfaces of the coal particles, and the agglomerates float to the surface where they are removed as concentrates. The associated mineral matter, wetted by the water, is not floated and is removed from the vessel as tailings. Figure 2.1 illustrates the flotation process.

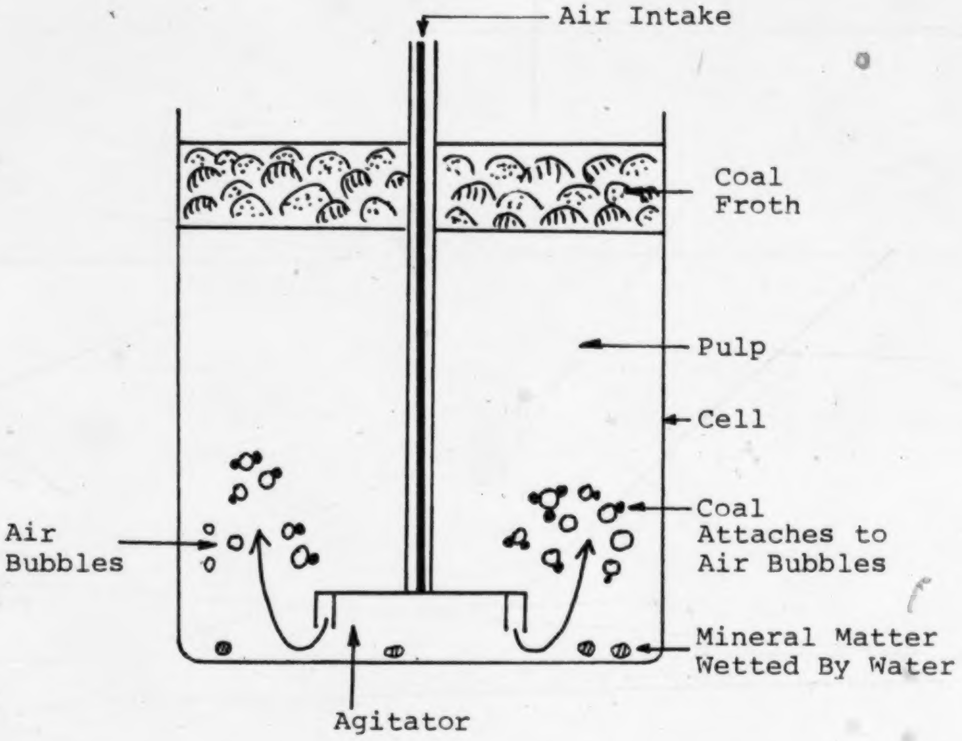

Figure 2.1 An Illustration Of The Froth Flotation Process

The flotation process is used in coal cleaning in western Canada, as one method of beneficiating fines in the feed to the preparation plants. The fines (-600 micron material) can account for about 40% of the plant feed. Western Canadian operators practice coal flotation in a single stage of rougher cells. The coals which can be cleaned by froth flotation are usually low and medium volatile bituminous coals.

There are many factors which can affect the performance of a coal flotation system, and, because the flotation process is based upon physico-chemical principles, the relationships are often ill-defined. For the purposes of the discussion which follows it is convenient to divide these factors into two groups. One, pertaining to the characteristics of the coal itself, is called **intrinsic factors** and the other, pertaining to the gross character of the flotation pulp and the equipment operating conditions, is called **extrinsic factors**. To illustrate, a few of the factors in each group are listed in Table 2.1.

The floatability of coals can differ greatly. The most widely accepted hypothesis to explain this phenomenon is the surface components hypothesis, which was proposed by Sun (1). It states that the heterogenous materials, such as various coals, carbons, and hydrocarbon minerals, consist of both floatable and non-floatable constituents. Their floatabilities are governed by the balance between these two groups of components. The flotation processes achieve

Table 2.1 Some Factors Which Affect Coal Flotation

INTRINSIC FACTORS	EXTRINSIC FACTORS
petrography	feed flow rate
rank	feed % solids
particle size	pulp level
particle shape	reagent dosages + addition points
particle density	aeration
oxidation	froth overload
liberation	pH + water quality
slime coating	impeller speed
	circuit configuration

separation due to differences in particle surface properties.

2.1.2 FACTORS AFFECTING THE FLOTATION PERFORMANCE OF COAL

2.1.2.1 PETROGRAPHY AND RANK

The petrographic composition of a coal can have a profound effect on the performance of the coal flotation system. Contact angle measurements indicate a broad range of natural hydrophobicity among the various lithotypes. While the order of decreasing floatability is apparently dependent upon the particular coal, in general VITRAIN > FUSAIN > DURAIN, with CLARAIN appearing anywhere in the sequence. The floatability of coal is also observed to increase with coal rank going through a maximum with the low volatile bituminous coals and decreasing for anthracite.

2.1.2.2 PHYSICAL PROPERTIES

The physical properties of coal particles can also affect the performance of the coal flotation system. As with most particulate sytems, the rate of flotation is observed to be size dependent. The distribution of rates exhibits a maximum in the intermediate sizes and decreases toward the coarse and fine particle extremeties. Miller et al. (2) found that the flotation rate increased, but the selectivity decreased with a decrease in particle size down to 150 microns (100 mesh). The flotation rate was constant for all sizes between 150 microns and 45 microns (325 mesh). Depending upon the exact nature of this distribution, flotation may be applied to particles in the range 600 microns (28 mesh) to 10 microns, although in western Canada it is more commonly used to prepare the -212 micron (-65 mesh) fine coals.

The effect of reducing the particle specific gravity is to increase the flotation rate of the coarser particles because of the lower density of the bubble/particle aggregate. Miller et al. (2) stated that there is an inverse relationship between coal particle specific gravity and floatability. This is a result of interaction between the organic components of coal, which are the most amenable to bubble attachment and have lower specific gravity, and the inorganic components, which are the least amenable to bubble attachment and have higher specific gravity.

Flotation rate is also observed to be dependent upon particle shape. Prismatic particles with plane faces and sharp edges have the highest rate of flotation which decreases with the appearance of irregular or grooved faces and/or rounded edges (Burdon and Mishra (41)).

Particle coatings such as the products of surface oxidation and/or attached clay slimes serve to reduce the floatability. For the former, the hydrophobicity is reduced through the formation of hydrophyllic acidic groups on the surface. Slime coatings prevent particle bubble attachment because of surface shielding.

Liberation is also important in determining the performance of a coal flotation system. The flotation rate for locked particles is substantially lower than for those which are perfectly liberated for reasons of particle density, surface hydrophobicity etc...

2.1.2.3 FLOW RATE AND PERCENT SOLIDS

For continuous systems the flow rate of pulp to the flotation cells can affect system performance by altering the mean particle residence time and hence the probability of flotation. The solids concentration of the feed pulp is also important since it too has an impact on particle residence time as well as on pulp rheology and particle-bubble collision probability. The solids concentration, s, in coal flotation is typically in the range of $3\% \le s \le 20\%$, although in western Canada the value of 10% is seldom exceeded and 7% appears to be about average.

2.1.2.4 PULP LEVEL

Pulp level (or alternatively the depth of the froth column) is an important factor in coal flotation principally through its impact on particle residence time in the froth and hence particle and water drainage to the pulp. Particle drainage is generally observed to be greater for gangue minerals and the coarse coal.

2.1.2.5 REAGENTS

Of all of the factors which have been investigated in coal flotation, reagents have received the most attention. While depressants and dispersants have been used to enhance selectivity, collector and frother are considered to be the most important reagents. Coal surfaces are generally expected to be naturally hydrophobic but this is not always the case and very often a collector is added to ensure hydrophobicity. Unfortunately, the use of oily collectors for coal (kerosene, diesel,...) can have an effect on froth quality. Collector additions can either increase or decrease solids recovery and the concetrate ash content. At low initial levels of collector, increases tend to enhance hydrophobicity and hence increase solids recovery. Where the initial level is near saturation with respect to hydrophobicity, additional collector will counteract the effect of frother and reduce the mobility of the froth enhancing drainage. (Coal flotation froths are inherently immobile because of the heavy particle loading and in most cases froth paddles must be used to ensure removal.)

Frother increases tend to increase water recovery and froth mobility. Such an effect may be useful in overcoming froth overloading, however, as water often entrains fine gangue, this can lead to froth product contamination. The most widely used frother is methyl isobutyl carbinol (MIBC)'.

Miller (3) working on the Appalachian coals has observed that coals floated readily with only frother in absence of collector. The clean coal yield increased with the addition of oily collector at the starvation frother addition level. Taylor, Miller, and Deurbrouck (4) concluded that the xanthates were not effective as collectors of coal from coal-pyrite feed due to the poor adsorption capacity and flotation results with the xanthates as collectors. In contrast Petrovich (5) stated in his patent that polyhydroxy alkyl xanthate was an effective depressant for pyrite in coal. Other depressants sunch as Na_2SiO_3, Na_2SiF_6, and dextrines were tested by Botha (6) and were found not to be very effective on the South African coals. The yield of coal improved when frother was added to the cells at more than one point in the cell bank, and the yield deteriorated when froth was washed with a water spray (Nguyen and Cheh (7)). Higher dosages of frother caused a higher ash content in the concentrate (Botha (6)). Plouf (8) suggested that increasing fuel oil and decreasing frother were not beneficial to the yield, but increasing fuel oil was beneficial. Solari and Rubio (9) found that the yield of low-rank Brazilian coal fines by flotation was at a maximum in the presence of pine oil

---

'MIBC is also known as 4 methyl - 2 pentanol.

as collector and frother, using sodium silicate as an ash depressant with prior desliming of the feed to -200 mesh.

2.1.2.6 AERATION

The rate of flotation is observed to increase with an increase in the air flow rate, because of an increase in the number of bubbles available for collision. Large air bubbles generally correspond to poor flotation results presumably because of the consequent decrease in bubble particle collision probability. Smaller bubbles provide for optimum flotation conditions. The homogeneous dispersion of bubbles in the flotation pulp is also important to achieve the greatest probability of the coal particle and air bubble collision (Gaudin (43)).

2.1.2.7 WATER CHEMISTRY: pH

The dissolved salt content and the pH of the flotation pulp can have an effect on the performance of the coal flotation system. While, in general, coal flotation is obtained with $3 \leq pH \leq 8.5$ (Kelebek, Salman, and Smith (10)), some systems may require pH adjustment to enhance pyrite depression, counteract the presence of humic materials, etc... Dissolved salts will govern the electrokinetic behaviour of the coal particles and may therefore affect flotation performance.

2.1.2.8 CONDITIONING TIME AND IMPELLER SPEED

Conditioning in coal flotation is important in the dispersion of reagents and in particular to allow sufficient time for collector adsorption (Miller (11)). However, most circuits for the higher rank coals do not include this step in the flowsheet preferring to add the reagents at the front end of the flotation circuit. Impeller speed is important since it controls the mixing conditions within the cell and has an effect on the bubble size distribution.

2.1.2.9 CIRCUIT CONFIGURATION

Circuit configuration is becoming an increasingly important consideration in coal flotation system performance as the process is applied to lower rank and "difficult" coals. Historically, coal flotation has been carried out in a simple rougher circuit, however, rougher-scavenger-cleaner circuits as well as separate "sand/slime" treatment schemes have recently been investigated and show promise (Firth, Swanson, and Nicol (12)).

2.1.2.10 FROTH OVERLOAD

Froth overload is often a significant factor in the plant flotation circuit. For example, if bubble production is reduced, the remaining bubble surfaces will be saturated with coal particles, and further flotation is inhibited. The existence of a heavily laden, and as a consequence, immobile froth is termed "froth overload". The behaviour of the froth under this condition is often unpredictable.

2.2 MODELLING THE FLOTATION PROCESS

2.2.1 APPLYING FLOTATION MODELS

The kinetic data derived from a single batch flotation test provides a tabulated set of estimates of the measured/calculated process variables at specific points in time. The minimum set of information which is probably necessary regarding the concentrate and tailings products is:

a) the mass of solids and water in each product.

b) the ash assay of the product solids.

In order to carry out a further analysis, it is necessary to adopt a (conceptual) physical model of the slurry. Standard practice in both coal and base metal flotation is to begin with a three component system (34):

a) valuable mineral (organics).

b) gangue mineral (ash[2]).

c) water.

Figure 2.2 shows this physical model. Clearly, the physical model is a simplification of the real system, but, based

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[2] Although, strictly speaking, the mineral matter is the true physical component in the system, for a particular coal with a constant mineral matter to ash ratio, the ash measurement is proportional to the mineral matter content. Moreover, the ash content is of greater interest since it is one of the principal attributes in determining coal quality.

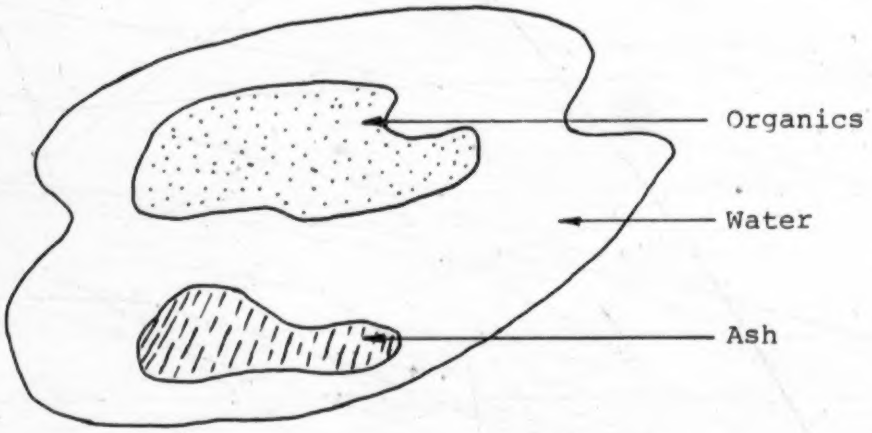


Figure 2.2 A Conceptual Physical Model Of The Slurry

upon past experience, it is an acceptable representation for modelling purposes. From the minimum set of data and the physical model, a material balance is carried out, and the recoveries of each component (organics, ash and water) as a function of time are obtained. It is then possible to use flotation models to describe the kinetics of each component.

When, as in this thesis, there are a large number of flotation tests to be compared, tabulated data is difficult to analyze. However, kinetic flotation models can be used to reduce the experimental data and this facilitates the analysis.

The most common form of the batch flotation model is a mathematical formalism relating recovery to time, considering flotation as a rate process. If each data set can be characterized by a model, then the model parameters will carry the flotation system performance information. Since the models chosen are generally quite simple (≤3 parameters), the tabulated data can be significantly reduced which simplifies interpretation. In addition, since the models are time continuous interpolation is easily performed. If satisfactory recovery-time models can be derived from the data for each of these components then it is possible to predict the minimum set of information specified above.

Finally, it should be observed that with only minor modifications in most cases, these flotation models can be adapted to describe the continuous flotation system. Hence, they can be used in the analysis of plant data.

2.2.2 INTRODUCTION TO MATHEMATICAL MODELS

A model is a mathematical (functional) description of a unit (system) that behaves in an analogous manner to the unit being modelled. Hence the model can be used to study the operation of that unit. The models give fundamental understanding of a unit and can be used in process control, optimization, economic analysis, etc...

A wide spectrum of models may be developed to describe a single process. The adequacy of a given model should be judged principally on the basis of how well the model succeeds in meeting the purposes for which it was developed. If therefore follows that in the model formulation phase, one must have the intended use clearly in mind if a suitable model is to result.

Lynch et al. (13) have grouped models into empirical, mechanistic and phenomenological models. Empirical models depend only upon experience or observation without regard to science and theory with a "black box" representing a process. Mechanistic models conceive of natural processes as being machine like and are capable of explanation through the laws of physics and chemistry. Phenomenological models depend upon scientific descriptions of actual phenomena with avoidance of all interpretation, explanation or evaluation. The phenomenological models are the most widely accepted and are employed in this thesis.

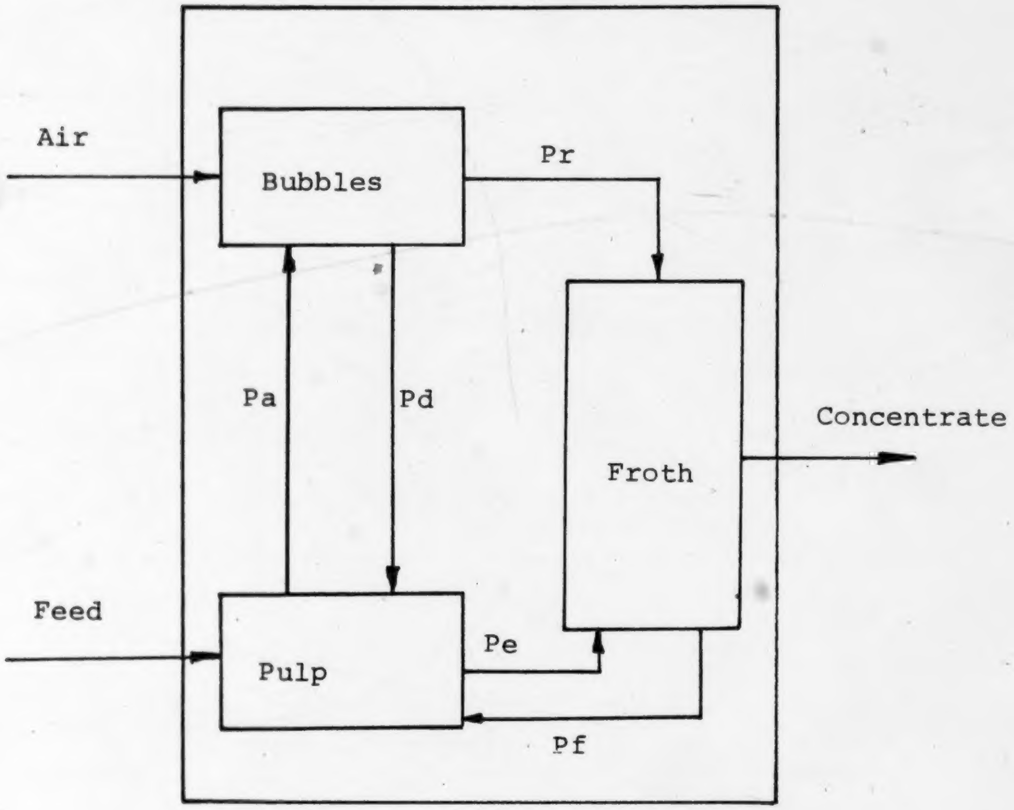
2.2.3 DERIVATION OF FLOTATION MODEL

Most of the models proposed to describe the flotation process are phenomenological models, and these models usually describe the recovery of valuable minerals (or components) as a function of time. These models are based upon the laws of probability and draw analogies with chemical kinetics.

The first probability model was proposed by Schuhmann (14). He stated that a sequence of events must occur before a particle can reach the concentrate. The flotation process is fundamentally a collision process, involving, at some stage, collision and then mutual attachment of air bubbles and mineral particles. This idea was advanced by Tomlinson and Fleming (15) by describing flotation in terms of probability of success or failure. Kelsall (16) developed a probability model which described a continuous flotation bank of a number of identical cells in series. Jowett and Safvi (17), while considering the probability theory, drew analogies between the flotation process and chemical kinetics. Lynch et al. (18) and others developed this analogy further. Some of these models are summarized by Klimpel et al. (19) and are listed in the next section.

The development of the basic flotation process model is summarized as follows:

Let Figure 2.3 represent the flotation process, then the probability of a particle reporting to concentrate via the flotation route (Pcf) is



Pa: probability of adhesion(or attachment)
Pd: probability of detachment
Pr: probability of flotation
Pf: probability of drainage
Pe: probability of entrainment

Figure 2.3 A Representation Of The Froth Flotation Process Model

$$Pcf = Pa(1-Pd)Pr(1-Pf) \qquad \ldots(2.1)$$

where: Pa = probability of adhesion (or attachment).
Pd = probability of detachment.
Pr = probability of flotation.
Pf = probability of drainage.

The probability of a particle getting to concentrate via entrainment (Pce) is

$$Pce = (1-Pa)Pe(1-Pf) \qquad \ldots(2.2)$$

where: Pe = probability of entrainment.

These probabilities are functions of equipment characteristics (impeller speed, bubble size and concentration, etc.) and of feed characteristics (pulp character, reagents, etc.).

The overall probability (P) of flotation in a cell is

$$P = Pcf+Pce \qquad \ldots(2.3)$$

One expression of this form could be written for every class and grade of particles in the pulp.

For a number (N) of cells, the probability of **NOT** recovering a certain species (Px) is

$$Px = (1-P)^N \qquad \ldots(2.4)$$

For a large N and a small P (P<<1), then

$$Px = (1-P)^N \approx \exp(-NP) \qquad \ldots(2.5)$$

where N is essentially a measure of flotation time and P is a form of the rate constant. This is the connection between the laws of probability and the chemical kinetics. Generalizing from probability expressions for specific particle classes to an overall probability, the mineral (or component) recovery (or yield (Y)) can be written as

$$Y = 1-\exp(-Kt) \qquad \ldots(2.6)$$

where: t = time.
K = rate constant.

The biggest weakness of the flotation models is their inability to account for the kinetics of froth removal. Provided that the rate limiting step is the removal of particles from the pulp to the froth, then first order approximations give reasonably good prediction.

2.2.4 CANDIDATE MODELS

There are several 2, 3 and 4 parameter kinetic (batch) models in common use and some were selected for evaluation on the Gregg River Resources data. The candidate model forms are listed below in three sections under primary, secondary and other models. The primary models include the models, which were found to be most successful by other researchers and which were derived specifically for this thesis. The secondary models include the models which Klimpel et al. (19) claimed to be sucessful. The other models include those which were not used in the Gregg River Resources data but have been used by others with some apparent success.

2.2.4.1 PRIMARY MODELS

Simple First Order: (2 Parameter)

$$R = Rm(1-\exp(-Kt)) \quad \text{...(2.7)}$$

where:
- R = cumulative recovery of a component in the concentrate stream at time t.
- Rm = equilibrium recovery (i.e. as $t \to \infty$) of the component.
- K = the first order rate constant for the component.
- t = flotation time.

This model assumes a first order reaction with an analogy made between chemical and flotation kinetics.

Compound First Order: (3 parameter)

$$R = (100-\phi)(1-\exp(-Kft))+\phi(1-\exp(-Kst)) \quad \text{...(2.8)}$$

where:
- ϕ = the fraction (%) of the component which is considered to be slow floating.
- Kf = first order rate constant for the fast floating portion of the component.
- Ks = the first order rate constant for the slow floating portion of the component.

Observe that in the case where $Ks=0$ Equation 2.8 defaults to Equation 2.7 with $K=Kf$ and $Rm=100-\phi$. This model recognizes that all particles do not have identical flotation properties, and it incorporates two rate terms describing fast and slow floating components. This model was proposed by Kelsall (16). (The symbol, ϕ, and the name, "phi," are used interchangeably in the thesis.)

Although, it is sometimes possible to postulate plausible physical reasons for the existence of both a slow floating and fast floating fractions, it must be remembered that, for the most part, flotation modelling is simply a curve fitting exercise. For whaterver reasons, it is frequently observed that the experimental data is best described by the three parameter model of Equation 2.8.

Klimpel's First Order: (2 Parameter)

$$R = Rm\left[1 - \frac{1}{Kt}(1-\exp(-Kt))\right] \qquad \text{...(2.9)}$$

This model, which was proposed by Klimpel (24) and by Huber-Panu, Ene-Danalache and Cojocariu (20), considers the first order general mass balance representation of a single flotation component.

Non First Order:(3 Parameter)

$$R = Rm\left\{1- \frac{1}{\left[(n-1)Rm^{(n-1)}kt+1\right]^{(1/(n-1))}}\right\} \qquad \text{...(2.10)}$$

where:
    n = reaction order and $n>1$.

This equation assumes that the order of reaction is greater than one.

Zero/First Order: (3 Parameter)

$$R = \dot{R}mt \qquad t \leq tc$$

$$R = Rm(1-\frac{\dot{R}m}{Rm}tc)\exp(-k(t-tc)) \qquad t>tc$$

...(2.11)

$$tc = \frac{1}{k}$$

where:
$\dot{R}m$ = the zero order rate of recovery of the component.
tc = the time at which the flotation process changes from zero to first order kinetics.

This model, derived specifically for this project, assumes that the rate of removal of the component from the pulp may be limited in the early stages of flotation due to froth "freezing," giving rise to zero order kinetics.

First Order + Entrainment: (3 Parameter)

$$\frac{dC}{dt} = -k(C-C\infty)-\frac{K_1QC}{V}$$

...(2.12)

$$R = 100(1-\frac{C}{Co})$$

where:
dC/dt = change in component centration in the flotation cell holdup, as a function of time.
C = concentration of the component in the flotation cell holdup at time t.
Co,C∞ = the initial (t=0) and final (t=∞) values of C.
V = cell holdup volume.
K_1 = a constant governing the amount of entrainment.
Q = volumetric flow rate of water to the overflow at time t.

This model, derived specifically for this project, assumes that the rate of removal of the component from the cell holdup is the combined result of first order kinetics (Equation 2.7) and solids entrainment by the water.

It should be observed that, with the exception of Equation 2.11, the other expressions cannot accommodate froth overloading or "freezing". While this phenomenon is not commonly observed in laboratory testing it happens with some regularity in the plant and must be borne in mind when examining plant kinetic data.

2.2.4.2 SECONDARY MODELS

Klimpel et al. (19) claimed success in modelling a flotation process with Equation 2.9 and three other equations, which were also tested on the Gregg River Resources Data. These three equations are listed below.

Particle Floatabilities Proportional To Size Distribution: (3 parameter)

$$R = Rm\left[1-\frac{\exp(-Klt)-\exp(-kut)}{(Ku-Kl)t}\right] \qquad \ldots(2.13)$$

where:
Kl = rate constant for lower size of rectangular, conditional size distribution.
Ku = rate constant for upper size of rectangular, conditional size distribution.

This model was proposed by Huber-Panu, Ene-Danalache and Cojocariu (20). Considering the fact that a mineral assembly consisted of a number of discrete size distributions, this model assumes that there is a linear dependence between floatability and particle size. Furthermore, in the case where Ku=0, this equation defaults to Equation 2.9.

Simple Second Order: (2 parameter)

$$R = \frac{Rm^2kt}{1+Rmkt} \qquad \ldots(2.14)$$

This model was proposed by Arbiter (23) and also by Imaizumi and and Inoue (21) and Bull (22) in slightly different forms. This model assumes that the flotation has a monodisperse feed with particles having a constant floatability. It draws analogies with the time concentration for a series of fully mixed reactors and/or with general gas/solid adsorption kinetics.

Second Order With A Distribution Of Floatabilites: (2 parameter)

$$R = Rm\left[1-\frac{1}{kt}(\ln(1+kt))\right] \qquad \ldots(2.15)$$

This model was proposed by Klimpel (24). It considers the second order general mass balance of a flotation component.

2.2.4.3 OTHER MODELS

Other models, which are not used in the Gregg River Resources data but common are listed below.

First Order Two Stage: (3 parameter)

$$R = Rm\left[\left(\frac{Kp}{Kp-Kc}\right)(1-\exp(-kt))-\left(\frac{Kc}{Kp-Kc}\right)(1-\exp(-Kpt))\right] \quad ...(2.16)$$

where:
    Kp = rate constant describing transfer from pulp to froth.
    Kc = rate constant describing transfer from froth to concentrate.

This model was proposed by Meyer and Klimpel (25). It considers flotation as a two stage process and incorporates rate terms describing the mass transfer of a component from the pulp to the froth and from the froth to the concentrate.

First Order Reversible Model: (3 parameter)

$$R = \frac{KpRm}{(Kd-Kp)}\ 1-\exp(-(Kp+Kd)t) \quad ...(2.17)$$

where:
    Kd = rate constant describing drainage from froth to pulp.

This model was proposed by Harris and Rimmer (26). While considering the previous model, this model takes into account froth drainage.

Fast And Slow Floating Components: (4 parameter)

$$R = (Rm-\phi)\left[1-\exp(-Kft)\right]+\phi\left[1-\exp(-Kst)\right] \quad ...(2.18)$$

In case where Rm=100, this equation defaults to Equation 2.8. This model was proposed by Jowett (27). He argued that the assumption of an ultimate recovery of 100% (from Equation 2.8) was inadequate and added an ultimate recovery parameter.

3. EXPERIMENTAL AND ANALYTICAL PROCEDURES

3.1 EXPERIMENTAL DESIGN

A series of screening tests were performed to identify those factors which play a significant role in governing the flotation behaviour , and a series of modelling tests were performed in an attempt to develop a "comprehensive" model of the flotation system. In both the factor screening and the modelling tests, orthogonal design principles were used to simplify experimental organization and to facilitate the regression analyses. For the screening series a fractional factorial design was adopted. For the modelling series a full factorial design was adopted including star points for estimating second order effects. Several centre point runs were performed in each case (Murphy (28) and Bacon (29)). The details of the experimental designs are presented in sections 4.2.2 and 4.4.2 for the screening and modelling tests respectively.

3.2 SAMPLE ORIGIN AND PREPARATION

In the late fall of 1982, a bulk sample of the Gregg River Resources coal was picked up at the minesite and returned to the university laboratories for use as the flotation feedstock. The sample, weighing approximately 440 kg, was apparently obtained from drill cuttings from one of the coal seams in the "NO" pit. The representativeness of the sample can be questioned since it:

a) comes from a very restricted geological area.

b) represents the raw coal of this area in general and may not represent that fraction of the material which would find its way to the coal flotation circuit.

c) may not show the characteristic mineral matter association since the amount of dilution (extraneous material) would tend to be minimized.

Despite the unresolved question of sample representativity, the experimental work was expected to provide some valuable insight into the flotation system.

The bulk coal sample was air dried and mixed to near homogeneity by coning. A quarter of the cone was extracted and screened at 212 microns (65 mesh) on a SWECO vibrating screen. The -212 micron material was thoroughly mixed and then divided by riffling into 1 kilogram samples for use as the flotation feed solids for individual experiments. All of these feed samples, as well as the reject materials, were packaged in air-tight containers to prevent possible alteration of the surface properties by aging in air. The bulk sample, as received, assayed approximately 15% ash, and 48% by weight of the -212 micron fraction, which assayed about 12% ash. The size distribution of the bulk sample is shown in Table 3.1. It was argued that for a raw coal of approximately 15% ash, the feed to the flotation circuit may well be on the order of 12% ash since the flotation process is preceded in the flowsheet by a two-stage auto-medium cyclone circuit.

Table 3.1 The Size Distribution Of The Bulk Sample

Size (Mesh)	Wt. %
+ 10	10.90
- 10+28	16.90
- 28+42	11.00
- 42+48	3.50
- 48+65	9.80
- 65+100	8.54
-100+200	14.15
-200+325	7.85
-325	17.36

In addition to the solid sample, several drums of water were also obtained during the visit to the minesite. The water was used in pulping the solids material for the flotation tests. (It is worthy of note that tests conducted with Edmonton city tap water gave virtually identical flotation results.)

3.3 THE FLOTATION MACHINE

A modified laboratory flotation machine was used to perform all of the flotation tests. Developed in the university laboratories by McIntyre (30), the device is a hybrid between the standard WEMCO laboratory model and the LEEDS cell (Liddell and Dunne (31)). The flotation cell is a scaled model of the 8.5 m^3 (300 ft^3) WEMCO flotation cell used in the circuitry of several western Canadian coal preparation plants. According to McIntyre, the laboratory device retains the best features of both parent units. It is equipped with a mechanical froth scraper which serves to minimize the errors commonly introduced by the operator using traditional methods of froth removal. The unit also includes manual air flow control (rotameter), automatic pulp level control, a variable speed impeller drive and a torque arm to allow an estimate of power consumption. The machine is shown in Plate 3.1.

One of the primary requirements of batch flotation testing is that the results be reproducible, to avoid ambiguity in their interpretation. One of the principal

Plate 3.1 The McIntyre Flotation Machine

error sources, which has a deleterious effect on reproducibility, is the traditional (manual) method of froth scraping. Unless the operator is very experienced the error contribution can be significant. Moreover, using this method with two different operators will almost always result in a data set "discontinuity". Since the cell described above is nearly fully automatic in this regard, and in most other ways, it is expected that operator error will be minimized thus ensuring results of reasonable integrity.

Since the reproducibility of the flotation equipment had not been examined in the previous work (30), this was included as part of this project. The data used in the analysis was taken from the centre point runs associated with the screening and modelling experimental designs. Figures 3.1 to 3.4 illustrate both the cumulative recovery of solids and cumulative ash versus flotation time for the respective set of runs. Each flotation increment is labeled with the mean variable value ($\bar{x}$) and the standard deviation (σ). Inspection of the standard deviation data for yield indicates a reasonable degree of reproducibility. Similar testwork on coal using a modified DENVER laboratory cell by Roberts et al. (32) has shown better reproducibility with σ's of approximately 1.1%. However, in the same work, using traditional methods the σ values were approximately 2.2%. Since the feed material material was different, it is impossible to draw comparisons between the performance of the two devices. One can probably safely assume that the

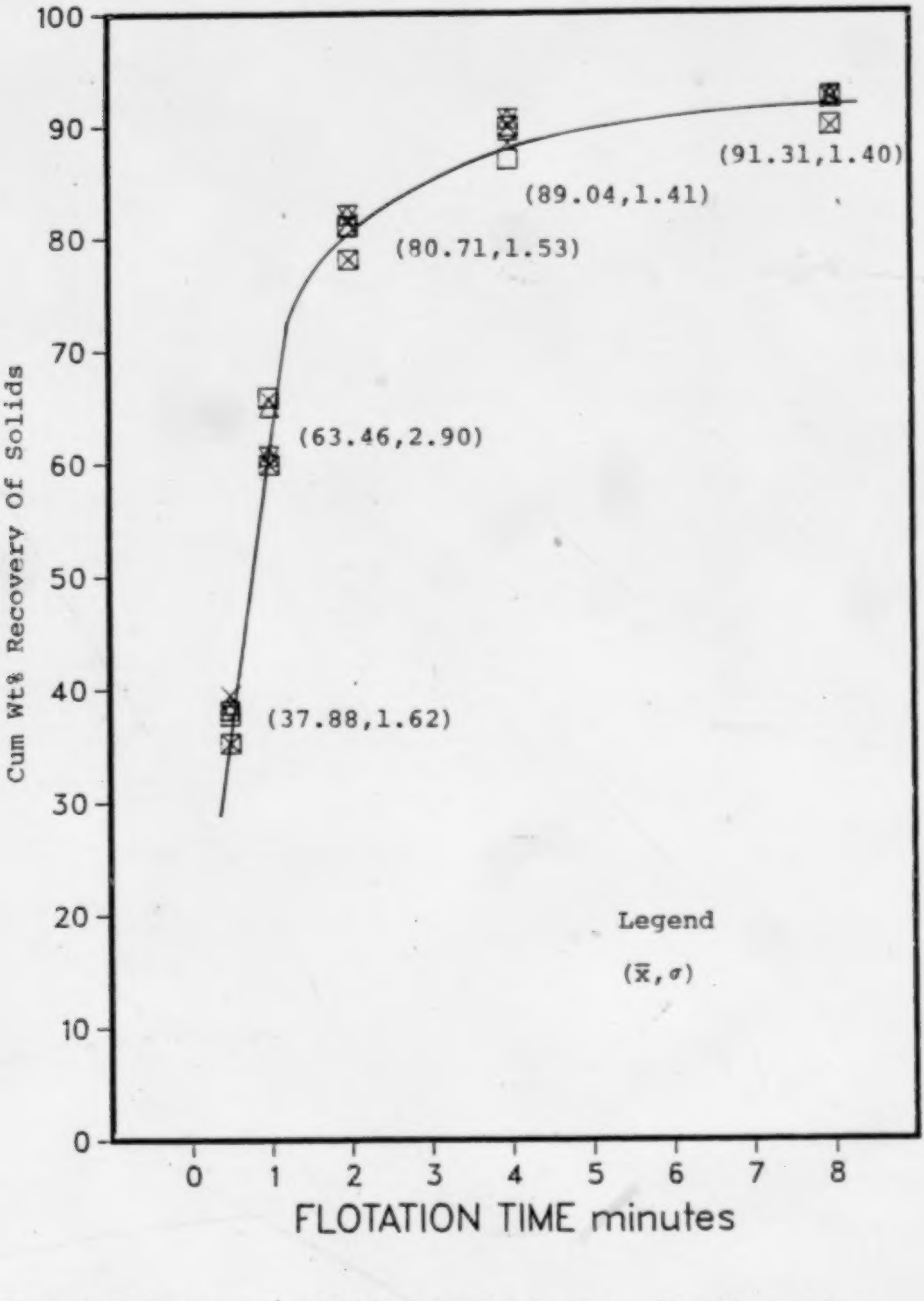


Figure 3.1 Reproducibility Analysis From The Screening Series Centre Point Runs For Cumulative Recovery Of Solids

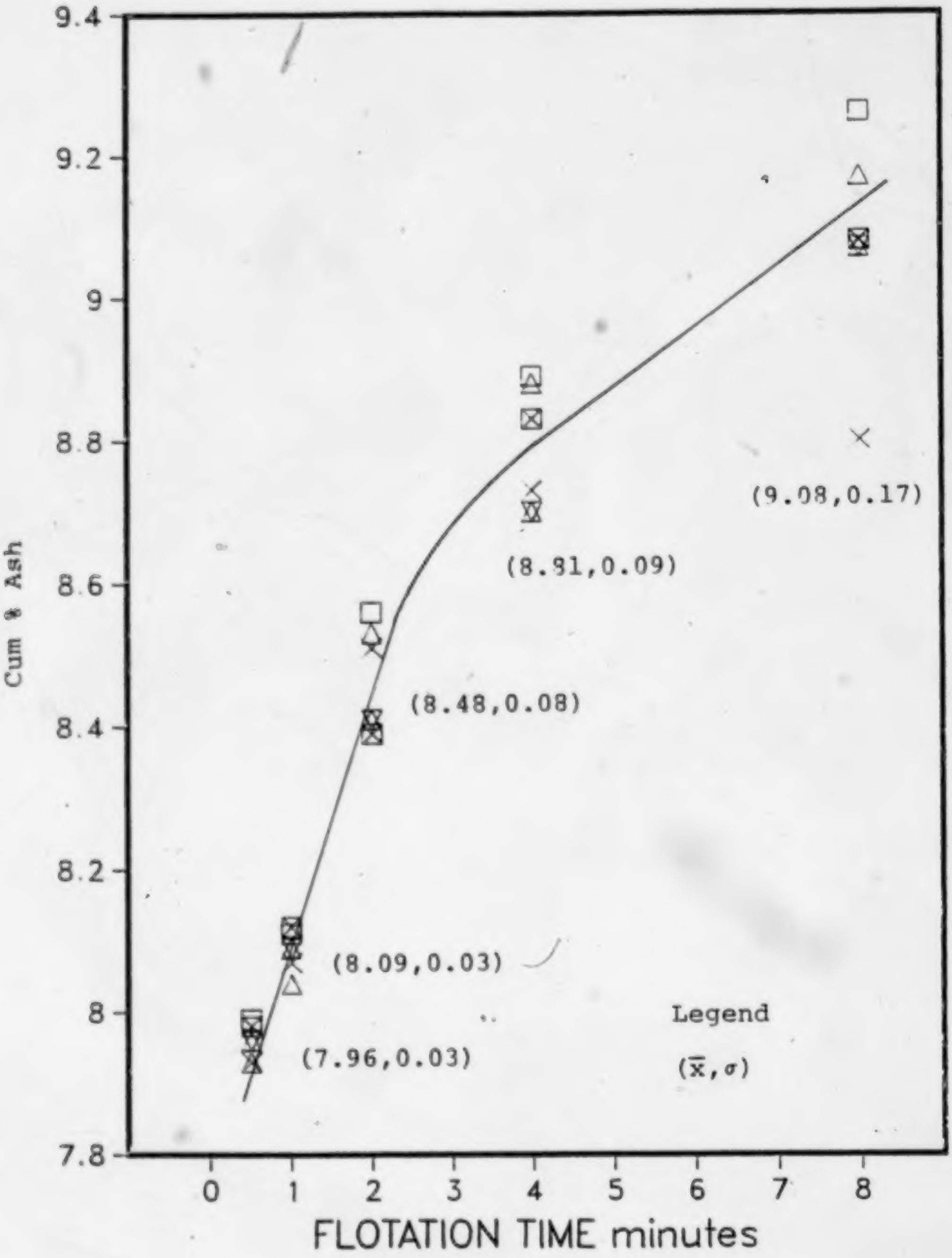


Figure 3.2 Reproducibility Analysis From The Screening Series Centre Point Runs For Cumulative Ash

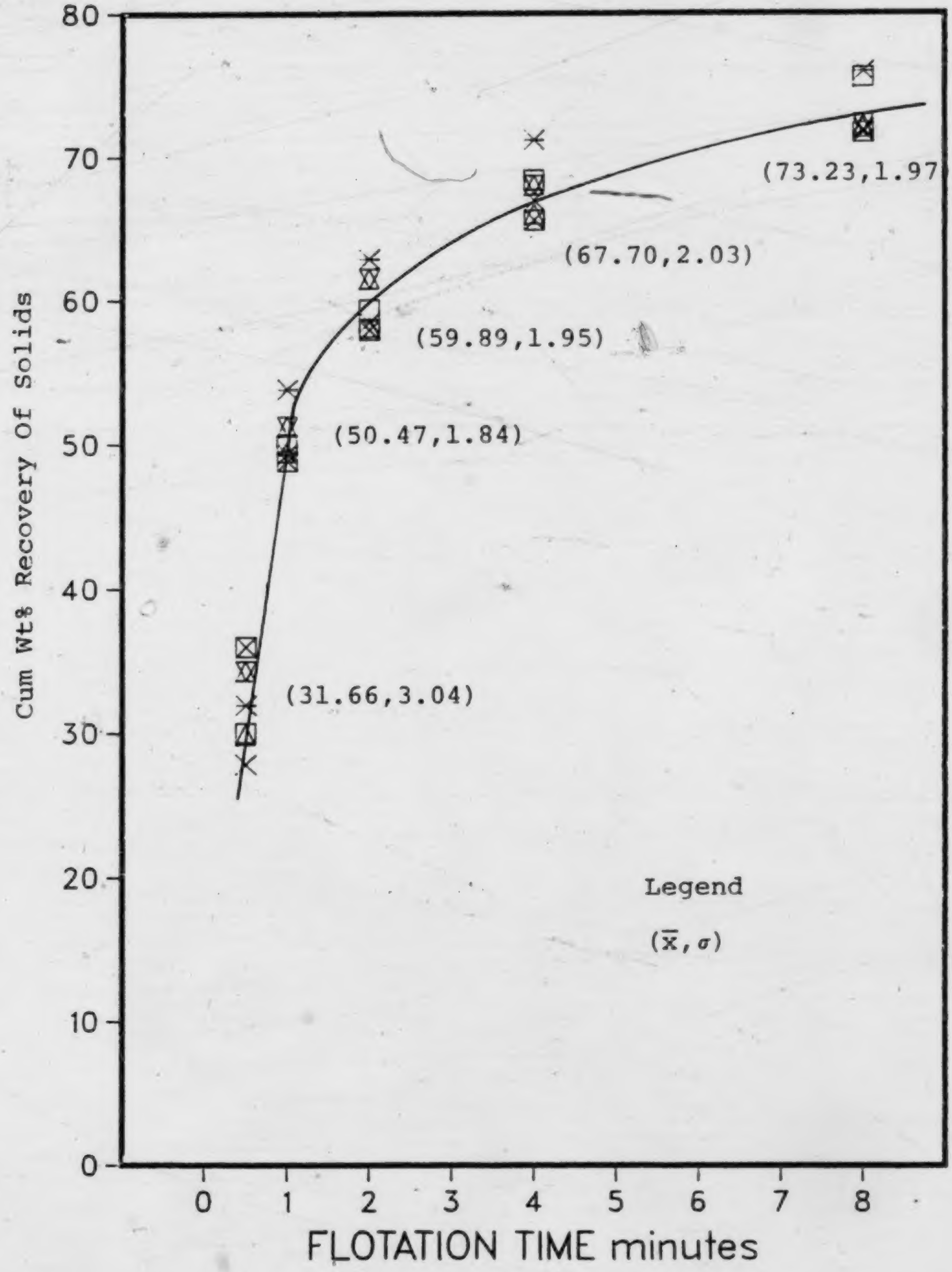


Figure 3.3 Reproducibility Analysis From The Modelling Series Centre Point Runs For Cumulative Recovery Of Solids

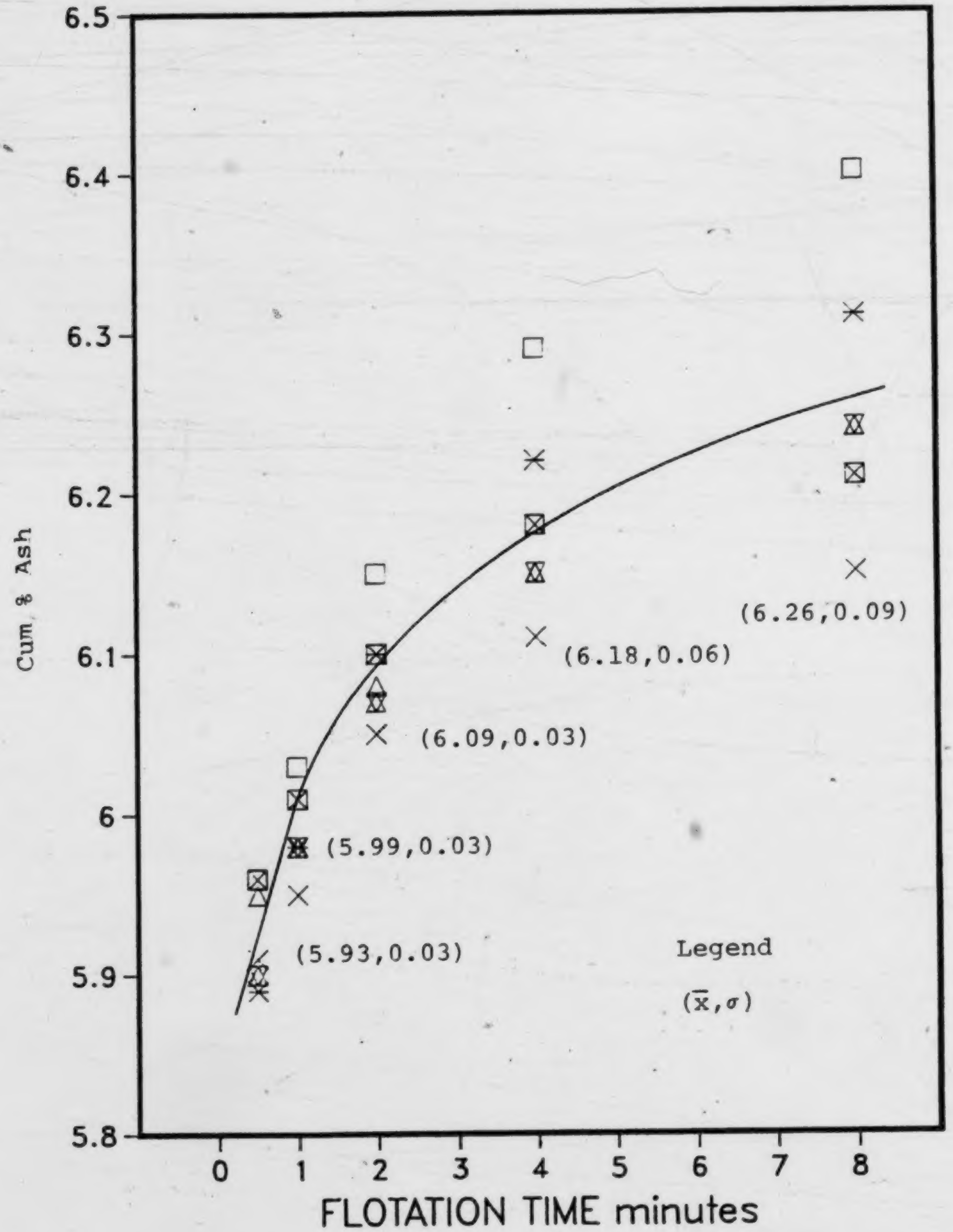


Figure 3.4 Reproducibility Analysis From The Modelling Series Centre Point Runs For Cumulative Ash

McIntyre unit is more consistent than its traditional (parent) counterparts.

A final comment must be made relative to Figures 3.1 to 3.4. For the purposes of this project the experimentally derived data were reduced using several simple mathematical models. Each of the models contains a parameter(s) which characterizes the equilibrium behaviour of the system, i.e. as $t \rightarrow \infty$, and a parameter(s) which characterizes the kinetic behaviour of the system, i.e. $t \rightarrow 0$. Typically, and as is evident on the figures, the system approaches near equilibrium conditions at about 4 minutes. Simplistically, for the five increment collection sequence illustrated on the figures, the first three data points contain the kinetic information and the latter two the equilibrium information. Given that each experimental data point contains both an information and a "noise" component, one might expect that maximizing the number of data points would improve parameter estimation. Unfortunately, this would also maximize the experimental workload. The five increment collection sequence was adopted as a compromise between these two considerations. Since there are only a few data points one might expect some problems in extracting model parameters. This subject will be covered in more detail in subsequent sections dealing with model selection and the impact of data error on parameter estimation.

3.4 EXPERIMENTAL PROCEDURE

For each experimental design (series), the flotation tests were conducted in a pseudo-randomized order to minimize the effects of uncontrolled factors such as sample aging. The procedure for completing an individual test is described below.

Each test began by filling the flotation cell with the prescribed amount of water and coal solids to meet the percent solids design point and the pulp volume criterion[3]. A sample of the reject feed material was saved for ash analysis. The pulp was then allowed 3 minutes to mix with the impeller speed set to 500 rpm. This step was performed to allow the coal some time to wet, similar to the action expected in the upstream processing in the preparation plant. Following this mixing step the pulp pH was checked and adjusted where necessary using lime. The impeller speed was set to the design level and the collector (diesel oil) and frother (MIBC) were added to the pulp, using calibrated micro-syringes, to meet the design reagent dosages. Immediately following the reagent addition the conditioning step was begun and subsequently the air valve opened and the flow rate quickly adjusted to the design level. After allowing about 5 seconds to establish a froth column, the mechanical scraper and the timer were started and the froth concentrate collection begun.

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[3] In several cases for the screening test series, the pulp volume in the cell had to be reduced and the test rerun because of severe flooding in the first run. This has the effect of slightly increasing the depth of the froth column which may alter performance to some degree.

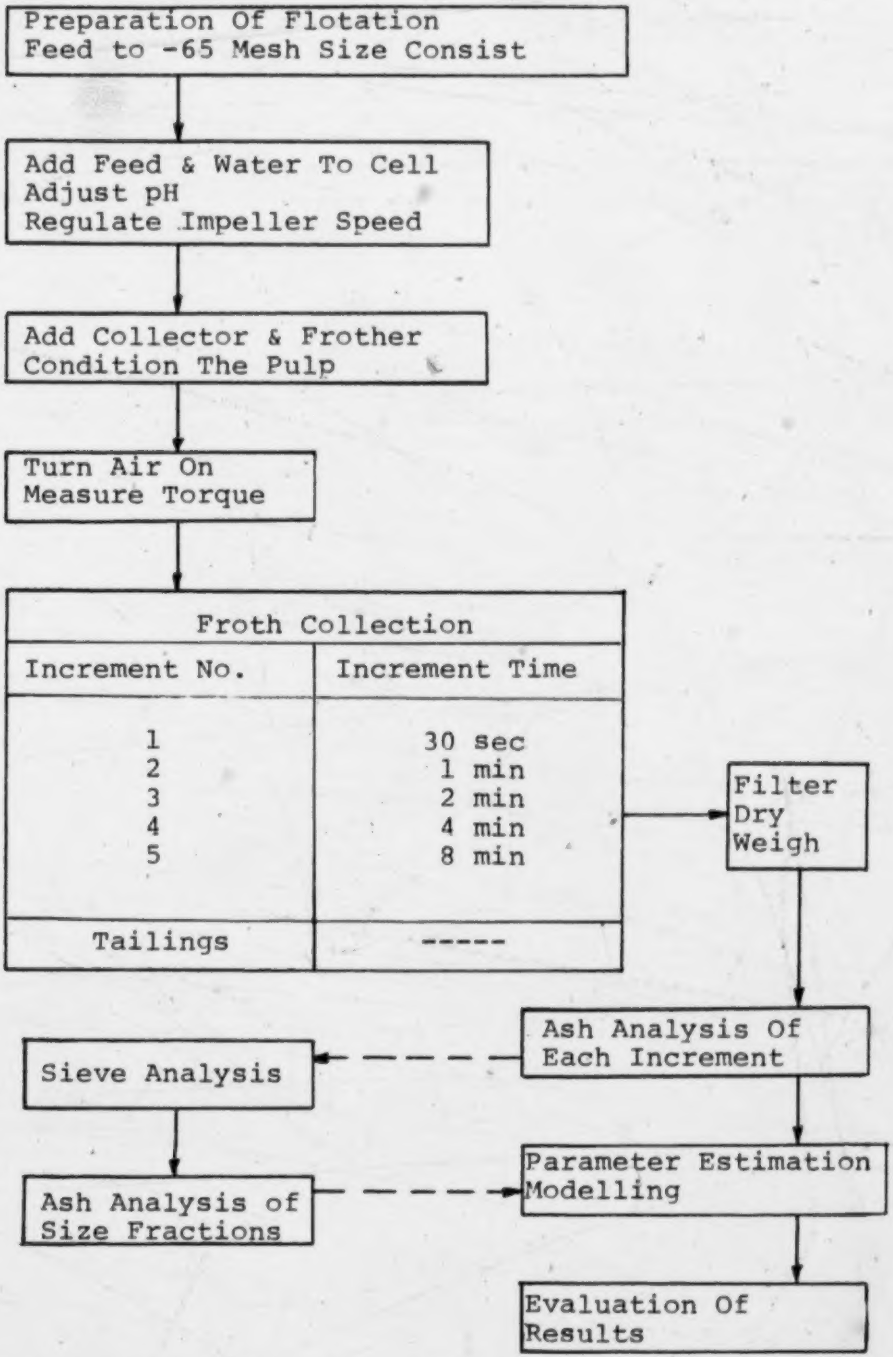
In an effort to provide maximum definition of the recovery versus time curves with a minimum of experimental effort a five increment concentrate collection sequence was selected. The end points (time) of collection were chosen as a geometric series (0.5 min., 1 min., 2 min., 4 min., 8min.) to partially compensate for the exponential behaviour of the solid component dissappearance kinetics. A few experiments were also carried out with an eight increment concentrate collection sequence (0.5 min., 0.75 min., 1 min., 1.5 min., 2 min., 3 min., 4 min. and 8 min.) to compare the range of data error against the five increment data.

During the increment collection the cell walls and impeller housing were periodically rinsed to remove attached particles. Water was also added automatically from a process water reservoir (pH adjusted) to maintain a roughly constant pulp level in the cell. Upon completion of the froth collection sequence, the equipment was shut down and the residual solids removed from the cell as the tailings product.

The corrected wet weights (for wash and rinse water) of the flotation products were recorded and the samples were filtered and the moist solids placed in a drying oven overnight at 100° C. Once dry, the sample weights were recorded and duplicate 3 gram samples were extracted for ash analysis. (Because the feed material was relatively fine, no further comminution was deemed necessary prior to this sampling step.) The ash analysis procedure was a modified form of the ASTM D3174-82 standard (33). The coal samples were placed in a furnace at 750° C for approximately 5 hours. Residues were always examined for dark discolouration to ensure complete combustion. The arithmetic mean ash value from the duplicate analyses was reported. In general, the back-calculated feed ash value agreed well with the result of the feed ash analysis. All of the raw data was then entered into a computer disk file for subsequent data processing.

Since particle size was not included as a factor in the tests, but has been known to affect flotation performance, a separate retrospective study was conducted. The experimental portion of the work involved obtaining samples of the reject material from the size composite analyses, screening these samples and analyzing the size fractions for ash. This was done for all 37 runs of the screening tests for each flotation increment as well as the tailings procuct. The sieves selected for the wet screening were 74 microns (200 mesh) and 44 microns (325 mesh) yielding information for three size fractions: +74, -74+44 and -44 microns.

The experimental procedure is summarized in flowsheet form in Figure 3.5.



Increment No.	Increment Time
1	30 sec
2	1 min
3	2 min
4	4 min
5	8 min
Tailings	-----

Figure 3.5 A Summary Of The Flotation Test Experimental Procedure

3.5 MODEL PARAMETER ESTIMATION

3.5.1 SELECTION OF A MODEL FOR THE FLOTATION SYSTEM

3.5.1.1 PARAMETER ESTIMATION TECHNIQUES

All of the equations {(2.7)→(2.15)} were fit on the basis of minimizing the unweighted least squares objective function:

$$J = \sum_{i}(R_i - \hat{R}_i)^2 \qquad \ldots(3.1)$$

where: J =sum of the residuals squared.
R_i =measured recovery at time "i".
$\hat{R}_i$ =predicted recovery at time "i", using a particular model.

The parameter estimates were obtained using the iterative solution techniques of non-linear regression (Draper and Smith (42)) for Equations 2.7 through 2.10 and 2.13 through 2.15, and an unconstrained multivariable search algorithm for Equations 2.11 and 2.12 (Hiller and Lieberman (35)). The differential equation in 2.12 was solved by the simple Euler method (Gerald (36)).

3.5.1.2 MODEL SELECTION

Without presentation of the raw data, the results of the parameter estimation[4] exercise are shown in Tables 3.2 through 3.5. Four tests (#12, #15, #19 and #20) were chosen at random from the screening series for this exercise. Parameter estimates for both the 5 and 8

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[4] The BMDP statistical package (37) and the author's own programs were used for the non-linear regression analysis.

Table 3.2 Comparison Of Model Parameter Estimation Data For Screening Series Test #12

Eqn #	Parameters	5 Increment Sequence Estimates				8 Increment Sequence Estimates			
ORGANICS		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	73.67	1.090		72.75	72.08	1.123		45.47
2.8	Phi,Kf,Ks	58.98	3.931	0.153	5.59	59.16	3.349	[illegible]51	5.49
2.9	Rm,K	79.79	2.42		41.09	78.10	2.46		25.32
2.10	Rm,n,K	92.12	2.67	0.001	17.37	84.76	2.65	0.001	103.94
2.11	R̊m,K ,Rm	62.32	1.392	79.74	155.05	59.85	1.383	69.04	225.10
2.12	K,K1,C∞	0.00	10.258	7.82	60.55	0.00	6.758	10.66	4.76
2.13	Rm,K1,Ku	50.00	1.0	0.50	1350.1				
2.14	Rm,K	83.92	0.0168		25.0				
2.15	Rm,K	50.0	1.00		1351.1				
ASH		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	44.29	0.808		26.58	40.49	0.878		13.11
2.8	Phi,Kf,Ks	75.80	2.818	0.050	6.39	76.38	2.374	0.042	3.40
2.9	Rm,K	48.10	1.75		17.13	44.24	1.878		8.19
2.10	Rm,n,K	57.62	2.708	0.001	8.207	50.55	2.76	0.001	35.57
2.11	R̊m,K ,Rm	25.84	0.923	42.78	62.39	26.65	1.127	38.59	70.18
2.12	K,K1,C∞	2.32	2.981	24.17	1.905	0.53	2.171	24.30	0.64
2.13	Rm,K1,Ku	48.33	1.752	0.001	17.36				
2.14	Rm,K	51.41	0.019		11.22				
2.15	Rm,K	50.00	1.00		107.1				
WATER		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	18.07	0.318		0.52				
2.8	Phi,Kf,Ks	92.57	0.850	0.014	0.04				
2.9	Rm,K	21.35	0.568		0.38				
2.10	Rm,n,K								
2.11	R̊m,K ,Rm	272.52	25.94	9.33	58.5				
2.12	K,K1,C∞								
2.13	Rm,K1,Ku								
2.14	Rm,K	59.17	0.001		4.28				
2.15	Rm,K	13.90	0.77		13.87				

P1, P2 & P3 refer to parameters in the list, respectively.

Table 3.3 Comparison Of Model Parameter Estimation Data For Screening Series Test #15

Eqn #	Parameters	5 Increment Sequence Estimates				8 Increment Sequence Estimates			
ORGANICS		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	77.78	0.845		68.54	72.36	1.041		29.62
2.8	Phi,Kf,Ks	61.73	2.889	0.177	4.74	54.12	2.109	0.125	2.30
2.9	Rm,K	84.89	1.81		39.75	79.33	2.167		14.72
2.10	Rm,n,K	98.76	2.51	0.001	18.11	87.05	2.582	0.001	116.95
2.11	R̂m,K ,Rm	47.99	0.961	75.11	151.38	54.47	1.210	69.04	156.19
2.12	K,K1,C*	0.00	13.383	6.87	40.85	0.04	4.724	5.20	13.98
2.13	Rm,K1,Ku	50.0	1.00	0.50	1339.5				
2.14	Rm,K	90.75	0.011		24.13				
2.15	Rm,K	50.00	1.00		1339.5				
ASH		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	50.65	0.676		27.65	45.83	0.815		12.82
2.8	Phi,Kf,Ks	74.17	2.187	0.062	3.10	72.85	1.815	0.049	0.98
2.9	Rm,K	57.37	1.41		18.81	50.73	1.653		7.48
2.10	Rm,n,K	68.70	2.57	0.001	9.06	58.94	2.62	0.001	50.68
2.11	R̂m,K ,Rm	27.39	0.862	49.34	70.60	27.18	0.987	43.48	71.50
2.12	K,K1,C*	1.47	5.592	24.88	8.67	0.00	2.649	21.72	5.42
2.13	Rm,K1,Ku	55.92	1.413	0.001	17.89				
2.14	Rm,K	60.21	0.013		11.15				
2.15	Rm,K	50.0	1.00		176.30				
WATER		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	11.63	0.393		0.10				
2.8	Phi,Kf,Ks	92.65	0.645	0.006	0.00				
2.9	Rm,K	12.92	0.718		0.04				
2.10	Rm,n,K								
2.11	R̂m,K ,Rm	3.14	0.468	10.71	0.729				
2.12	K,K1,C*								
2.13	Rm,K1,Ku								
2.14	Rm,K	47.84	0.001		3.59				
2.15	Rm,K								

P1, P2 & P3 refer to parameters in the list, respectively.

Table 3.4 Comparison Of Model Parameter Estimation Data For Screening Series Test #19

Eqn #	Parameters	5 Increment Sequence Estimates				8 Increment Sequence Estimates			
ORGANICS		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	84.79	1.094		19.66	88.13	0.949		1.29
2.8	Phi,Kf,Ks	15.94	1.108	0.008	29.42	15.53	1.009	0.044	1.10
2.9	Rm,K	92.78	2.26		30.75	97.43	1.915		3.83
2.10	Rm,n,K					100.00	2.549	0.001	235.56
2.11	R̂m,K ,Rm	60.73	0.932	84.16	2.55	59.31	1.149	86.11	22.06
2.12	K,K1,C=	0.09	0.640	15.04	29.11	0.46	0.000	11.61	3.86
2.13	Rm,K1,Ku	50.00	1.00	0.50	2094.3				
2.14	Rm,K	97.45	0.014		48.36				
2.15	Rm,K	50.0	1.00		2094.3				
ASH		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	60.65	0.846		8.25	66.28	0.668		1.13
2.8	Phi,Kf,Ks	44.39	0.950	0.019	10.65	43.22	0.797	0.035	0.18
2.9	Rm,K	67.43	1.69		8.90	74.63	1.291		0.26
2.10	Rm,n,K	61.36	1.078	0.626	12.22	83.5	2.44	0.001	146.73
2.11	R̂m,K ,Rm	36.53	0.901	59.73	6.40	32.45	0.839	64.00	22.58
2.12	K,K1,C=	0.52	0.984	39.73	9.49	0.25	0.326	31.93	1.54
2.13	Rm,K1,Ku	61.38	0.979	0.571	5.61				
2.14	Rm,K	73.22	0.114		10.47				
2.15	Rm,K	50.00	1.00		499.89				
WATER		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	24.87	0.488		3.17				
2.8	Phi,Kf,Ks	86.95	1.173	0.019	0.57				
2.9	Rm,K	33.03	0.945		2.893				
2.10	Rm,n,K								
2.11	R̂m,K ,Rm	11.00	0.657	27.37	13.43				
2.12	K,K1,C=								
2.13	Rm,K1,Ku								
2.14	Rm,K	100.0	0.001		89.92				
2.15	Rm,K								

P1, P2 & P3 refer to parameters in the list, respectively.

Table 3.5 Comparison Of Model Parameter Estimation Data For Screening Series Test #20

Eqn #	Parameters	5 Increment Sequence Estimates				8 Increment Sequence Estimates			
ORGANICS		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	96.15	1.812		2.70	96.19	1.736		6.41
2.8	Phi,Kf,Ks	8.98	1.985	0.187	1.39	4.53	1.758	0.036	7.61
2.9	Rm,K	100.0	4.60		4.83	100.00	4.202		19.86
2.10	Rm,n,K	100.0	2.99	0.001	54.03				
2.11	R̊m,K ,Rm	115.2	1.827	95.77	6.33	107.34	1.667	95.35	4.68
2.12	K,K1,C∞	1.22	1.207	2.59	0.184	0.83	0.00	4.34	2.17
2.13	Rm,K1,Ku	50.00	1.0	0.5	3903.0				
2.14	Rm,K	100.0	0.035		14.37				
2.15	Rm,K	50.0	1.00		3903.0				
ASH		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	77.51	1.540		1.878	73.69	1.511		4.09
2.8	Phi,Kf,Ks	25.71	1.660	0.025	0.76	28.81	1.597	0.018	4.22
2.9	Rm,K	82.69	3.48		1.95	80.01	3.231		8.00
2.10	Rm,n,K	78.43	1.23	0.638	0.476	73.36	1.74	0.088	151.7
2.11	R̊m,K ,Rm	81.87	1.673	76.46	8.43	76.86	1.67	72.12	12.23
2.12	K,K1,C∞	1.09	0.734	19.63	0.45	0.72	0.00	27.31	11.86
2.13	Rm,K1,Ku	83.01	3.478	0.001	1.96				
2.14	Rm,K	85.54	0.026		6.72				
2.15	Rm,K								
WATER		P1	P2	P3	RMS	P1	P2	P3	RMS
2.7	Rm, K	25.86	1.403		3.57				
2.8	Phi,Kf,Ks	78.97	2.119	0.012	0.37				
2.9	Rm,K	32.94	3.11		1.56				
2.10	Rm,n,K								
2.11	R̊m,K ,Rm	31.19	1.59	29.96	10.2				
2.12	K,K1,C∞								
2.13	Rm,K1,Ku								
2.14	Rm,K	100.0	0.001		102.3				
2.15	Rm,K								

P1, P2 & P3 refer to parameters in the list, respectively.

point increment collection sequences are presented to illustrate stability. The statistic chosen to measure the goodness of fit was the residual mean sum of squares (RMS):

$$RMS = \left(\frac{J}{N-P}\right) \qquad ...(3.2)$$

where: N =number of data points in the fit.
P =number of parameters in the model.

Table 3.6 presents the "global" (organics and ash components) measure of the goodness of fit, that is the sum of the respective RMS values. **On the basis of the data in this table, Equation 2.8 was selected as the standard model form to be used to reduce the Gregg River Resources flotation data. This selection is based solely on the goodness of fit and not on the parameter sensitivity.**

As mentioned in section 2.2.4.1, this model will default to Equation 2.7 when Ks approaches zero and a test was required to establish this condition. Since the model parameters are highly correlated (see output in Appendix III), the standard method of applying the "t-test" (Draper and Smith (42))is not applicable. The procedure adopted was to compare the RMS[1] values for Equation 2.7 and Equation 2.8. (Both models were fit to the experimental data as part of the data processing step.) If the former was less than 2/3 of the latter, then Ks was set to zero, Kf was set equal to K and ϕ was

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[1] In fact, the comparison is based on the sum of the residuals squared given by Equation 3.1.

Table 3.6 A Summary Of Model Performance for the Solids Components

Models Equation #	Average RMS Org	 Ash	Total
2.7	40.91	16.09	57.00
2.8	10.29	5.23	15.52
2.9	29.11	11.70	40.81
2.10	29.84	7.49	37.33
2.11	78.83	36.95	115.8
2.12	32.67	5.13	37.80
2.13	2171.9	10.71	2182.6
2.14	27.97	9.89	37.86
2.15	2172.0	261.1	2433.1

set to 100-Rm.

Strictly speaking, the method just described, which compares total sum of the residuals squared, is not correct. A "partial F-test" (Draper and Smith(42)) should have been performed to judge the statistical merit of adding the third parameter to the 2 parameter model. However, since there are very few degrees of freedom associated with the variance estimates required for such a test, the tabulated F statistic is quite large and would result in a general acceptance of the 2 parameter model in many cases. (Specifically, for acceptance of the 3 parameter model, RMS(3) ≤ 0.2 RMS(2).) This would occur even though the two parameter model is observed to provide inferior fits. It was for this reason that the simplified method was adopted.

3.5.2 SENSITIVITY ANALYSIS

3.5.2.1 THE EFFECT OF DATA ERROR ON PARAMETER ESTIMATION

In Figures 3.1 to 3.4 dealing with reproducibility, it is clear that each data point is subject to non-negligible error in the ordinate variable. This will be true for the (recovery, time) data points for the individual components as well. What is of concern is the impact that such errors will have on the parameter estimates for the compound first order model. That is, if the parameters are very sensitive to error then any genuine correlation which may exist between a parameter and the experimental factors may be masked by the "noise" introduced through data error.

To gain some appreciation for the effect of data error on parameter estimation the following exercise was conducted. The basic assumptions were:

a) the error in recovery at any particular time is normally distributed.

b) the errors in recovery at any two points in time are uncorrelated (questionable).

c) the error variance is homogeneous.

A computer program was written which was capable of estimating the standard error of the parameters for a given standard deviation of the data points. The solution procedure was to initially calculate a set of perfect (recovery, time) data points from a compound first order model. The perfect data were then perturbed using Monte-Carlo techniques and the parameter estimates on the perturbed data set obtained by non-linear regression. This perturbation-parameter estimation process was repeated 100 times and ultimately the mean parameter values and estimates of the parameter standard errors computed. As expected, the mean parameter values agreed very closely with those values used to generate the perfect data set. With respect to the standard error, the relationship to the standard deviation in the data is shown on Figures 3.6, 3.7 and 3.8. In all of the simulations the rate constants were fixed at more or

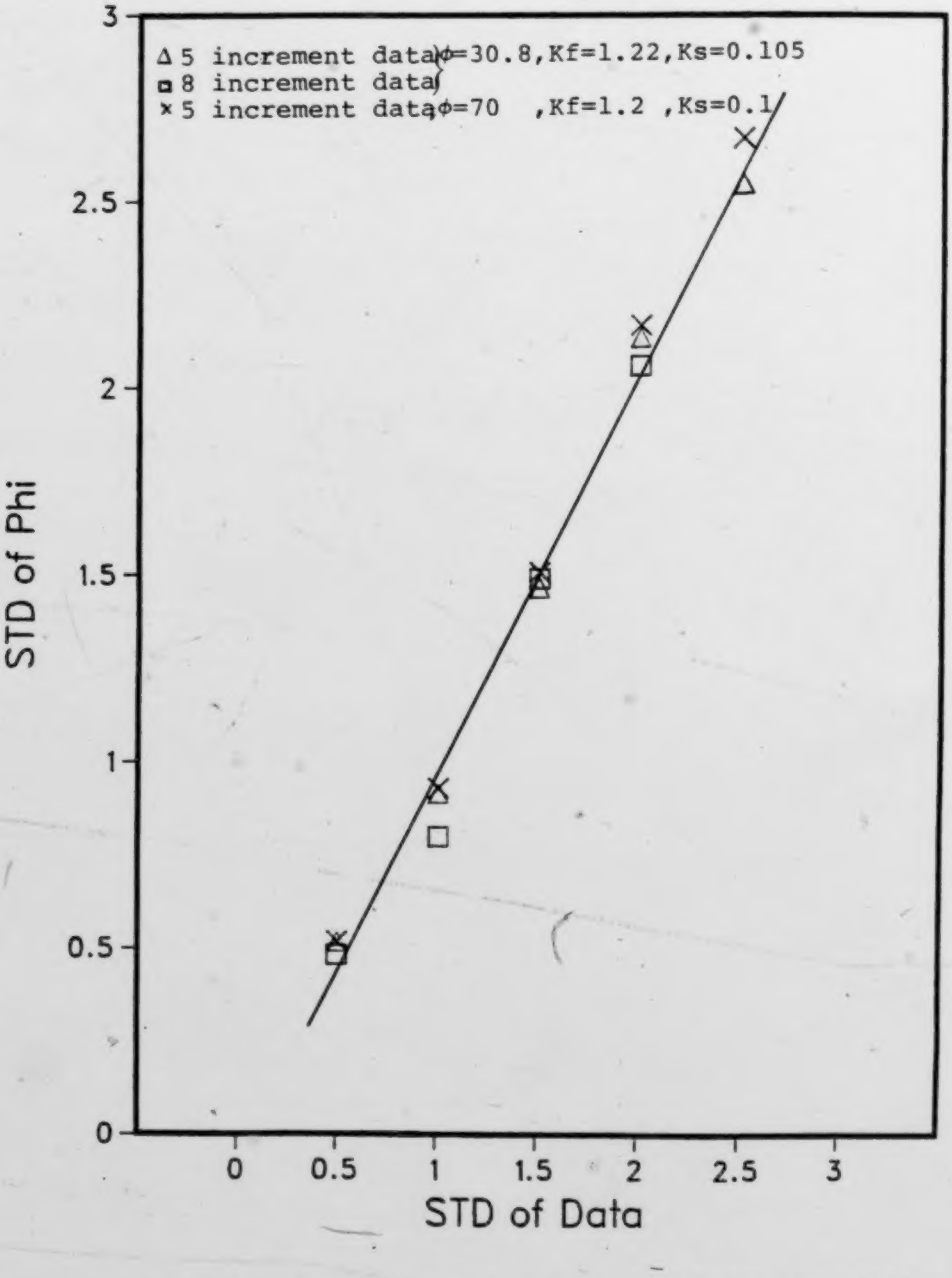

Figure 3.6 Standard Error of ϕ versus Standard Deviation of the Data

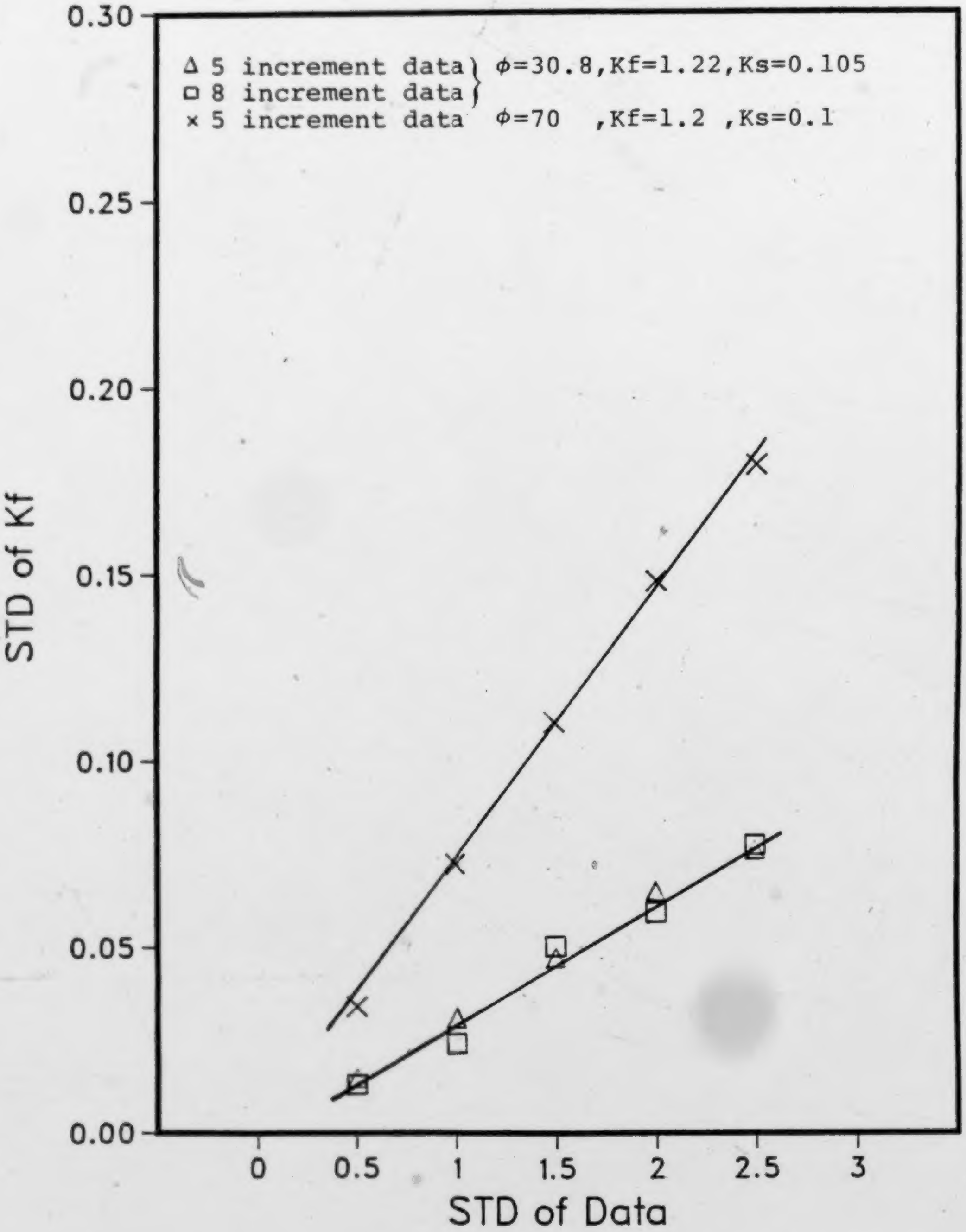

Figure 3.7 Standard Error of Kf versus Standard Deviation of the Data

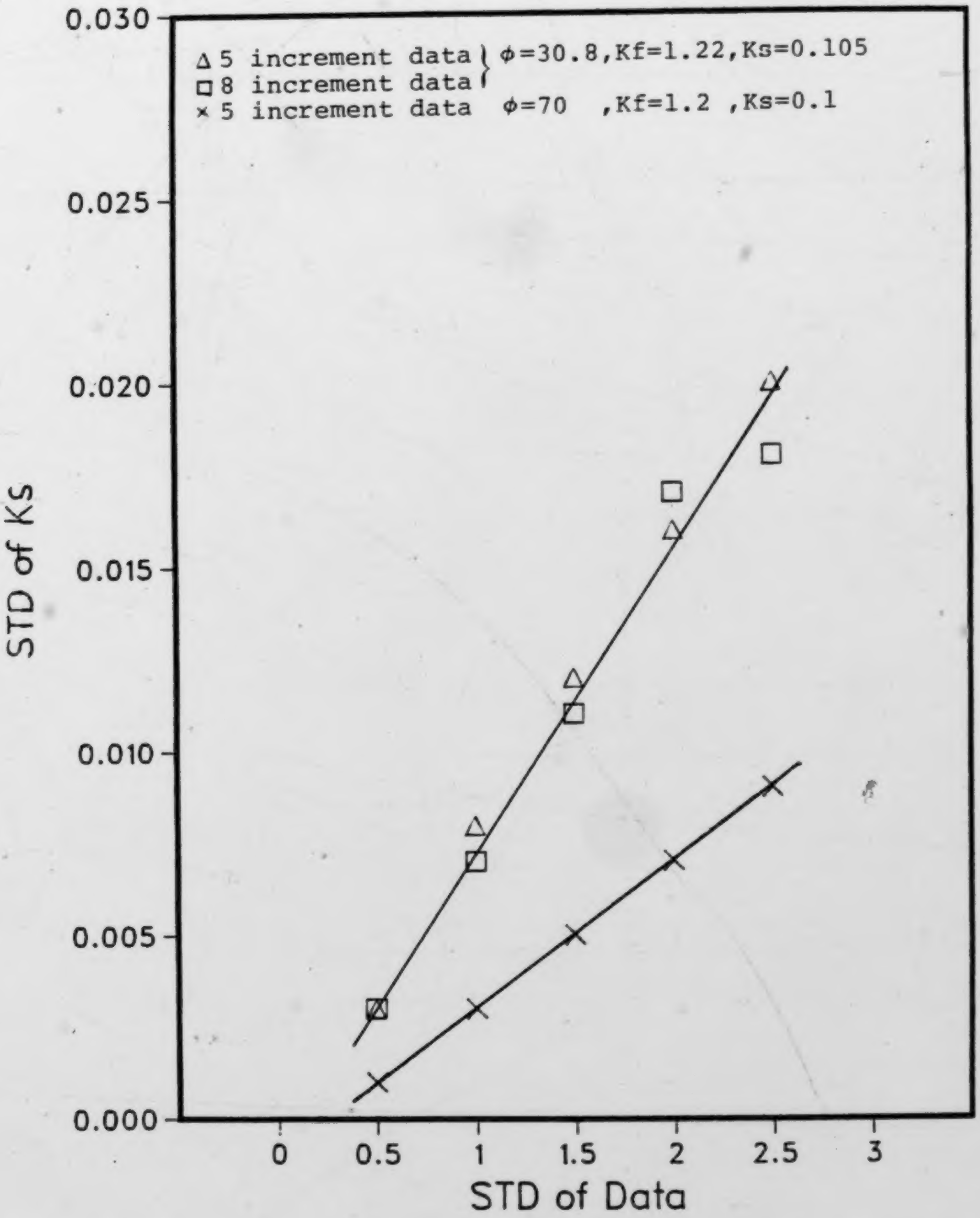

Figure 3.8 Standard Error of Ks versus Standard Deviation of the Data

less typical values; Kf=1.22 min^{-1}, Ks=0.105 min^{-1}. The first set of simulations were performed with ϕ=30.8% for both a 5 and 8 increment data set (ref. model selection). This portion of the exercise was intended to establish the merit of additional data. Inspection of the figures reveals essentially no difference in the relationships for the two data sets over a reasonable range of data error. (This justifies the adoption of the 5 increment collection sequence discussed in section 3.4.) Moreover, the relationship between the standard error of the parameter and the standard deviation of the data is observed to be linear. To examine the impact of ϕ, the variable expected to show the greatest variation, on the relationships a series of simulations were performed with ϕ=70%. The results indicate that while this has apparently no effect on the standard error of ϕ, the values for Kf and Ks are affected. The conclusion which can be drawn is that as the fraction of slow floating material increases, the standard error on Ks decreases while the corresponding value for the fast float fraction increases, and vice versa. Moreover, it seems that the standard error on the rate constants may be linearly related to ϕ over the range of data error studied. Further investigation of this relationship is beyond the scope of this project.

To illustrate the meaning of the results of the Monte-Carlo simulations, consider the case where the standard deviation of the data is 1.6%, a typical value for the solids components. Making the basic assumptions above and using data from the ϕ=30.8% relationships, parameter values must differ by:

ϕ: ±14.42%

Kf: ±0.367 min^{-1}

Ks: ±0.091 min^{-1}

to be significant at the 95% confidence level. Finally, it is apparent that in the strictest sense unweighted linear regression, while applicable to developing correlations with ϕ, cannot be used for Kf and Ks.

3.5.2.2 CONFIDENCE INTERVALS ON THE PARAMETERS

Klimpel et al. (19) also expressed concern over the sensitivity of a flotation model. They suggest that there are two major requirements for a flotation model. They stated that "first, a model must fit the observed data on the basis of goodness of fit, and second, each model parameter must have a range of statistical significance small enough such that changes in the flotation system can be confidently assessed (19)."

Klimpel et al. (19) proposed a method for estimating confidence intervals on the parameters which is based on lack of fit. Using Klimpel's method, a model is fit to the observed data by minimizing the residual sum of squares (as explained in section 3.5.1.1 and 3.5.1.2) to obtain the optimal parameter values. One by one, each of the parameters in the model is systematically varied from its optimal value. Typically the parameter in question is altered by (±10%, ±15%, ±20%,...) some amount, and the rest of the parameters are re-estimated by non-linear regression for each perturbation. The residual sum of squares associated with each point in parameter space can be transformed to a variance estimate and then statistically compared with the error variance estimated from the optimal solution. When the calculated F statistic exceeds the corresponding tabulated value, a confidence boundary is said to have been located. Positive and negative perturbations permit upper and lower boundary locations. When this exercise has been completed for the parameter in question the process is repeated with a new parameter until all of the parameters confidence limits have been defined.

This method is illustrated using the same data used in the previous section with the compound first order model (Equation 2.8) selected for the Gregg River Resources flotation data. Table 3.7 shows the results, and Figure 3.9 shows a graphical representation of the results for ϕ.

The results indicate that the confidence limits are 22.48 to 39.73 for the optimal ϕ value of 30.8, 1.04 to 1.48 for the optimal Kf value of 1.22, and 0.052 and 0.158 for the optimal Ks value of 0.105 at the 95% confidence level and that the confidence limits are not

Table 3.6 Effect of Parameter Error On Confidence Limit

$$R=(100-\phi)(1-\mathrm{Exp}(-Kft))+\phi(1-\mathrm{Exp}(-Kst))$$

F value from the table=F(3,2,1)=19.20

Change in Phi	Phi	Kf	Ks	RSS	Cal. F
+30%	40.04	1.46	0.156	7.61	20.13
+29%	39.73	1.45	0.154	7.15	18.91
+28%	39.42	1.44	0.152	6.70	17.72
+20%	36.96	1.37	0.139	3.65	9.65
+10%	33.88	1.29	0.122	1.21	3.20
Opt.	30.80	1.22	0.105	0.38	1.00
-10%	27.72	1.15	0.088	1.25	3.30
-20%	24.64	1.09	0.069	3.95	10.44
-26%	22.79	1.05	0.057	6.51	17.22
-27%	22.48	1.05	0.055	7.01	18.55
-28%	22.17	1.04	0.053	7.54	19.93

Change in Kf	Phi	Kf	Ks	RSS	Cal. F
+22%	39.16	1.49	0.148	7.56	20.23
+21%	38.83	1.48	0.146	7.10	18.78
+20%	38.49	1.46	0.144	6.57	17.37
+19%	38.16	1.45	0.143	6.05	15.99
+10%	34.91	1.34	0.127	2.18	5.77
Opt.	30.80	1.22	0.105	0.38	1.00
-10%	26.05	1.10	0.079	2.92	7.71
-13%	24.49	1.06	0.070	4.92	13.00
-14%	23.96	1.05	0.067	5.74	15.19
-15%	23.42	1.04	0.064	6.66	17.61
-16%	22.87	1.02	0.060	7.66	20.27

Change in Ks	Phi	Kf	Ks	RSS	Cal. F
+51%	39.16	1.41	0.159	7.41	19.60
+50%	39.00	1.41	0.158	7.14	18.88
+49%	38.83	1.40	0.157	6.88	18.18
+30%	35.71	1.33	0.137	2.83	7.48
+10%	32.42	1.25	0.116	0.65	1.72
Opt.	30.80	1.22	0.105	0.38	1.00
-10%	29.19	1.19	0.095	0.65	1.71
-30%	26.04	1.12	0.074	2.76	7.30
-50%	23.01	1.06	0.053	6.84	18.80
-51%	22.87	1.06	0.052	7.09	18.75
-52%	22.72	1.06	0.051	7.34	19.42

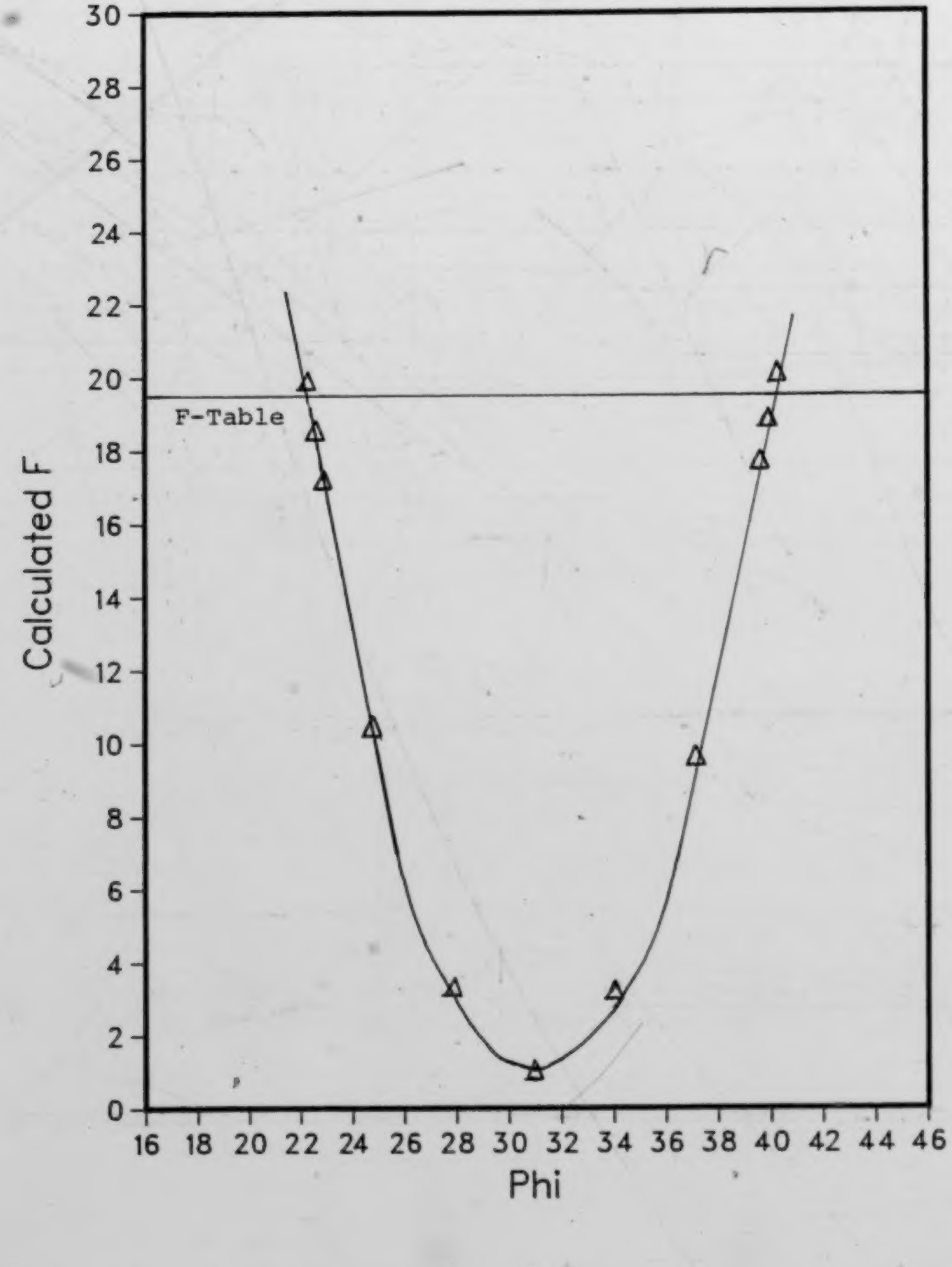

Figure 3.9 Parameter Confidence Limit Of ϕ

quite symmetrical. (In practice, it is usually sufficient to report the confidence limits as being symmetric.)

3.5.2.3 COMPARISON OF THE PARAMETER SENSITIVITY TESTS

Comparing Klimpel's method and the Monte-Carlo method, one difference is most apparent.

There is a large discrepancy in the parameter confidence limits obtained by these two methods. The confidence limits obtained by the Monte-Carlo method are much smaller (by almost an order of magnitude) than those obtained by Klimpel's method. Table 3.8 shows a comparision of confidence limits for the compound first order model for a particular component when the standards deviation of the data is assumed to be 0.44%.

The difference in the magnitude of the confidence limits indicates the inconsistency between the two methods. This difference is studied graphically in two dimensions, using the simple first order model (Equation 2.7). The confidence limits were generated for the parameters, Rm and K (see Chapter 10 in Draper and Smith (42)) and are shown in Figure 3.10. The confidence limits obtained by Klimpel's method‘ and the Monte-Carlo methods are shown for comparative purposes.

It is most correct to talk about the confidence regions obtained by the method described by Draper and

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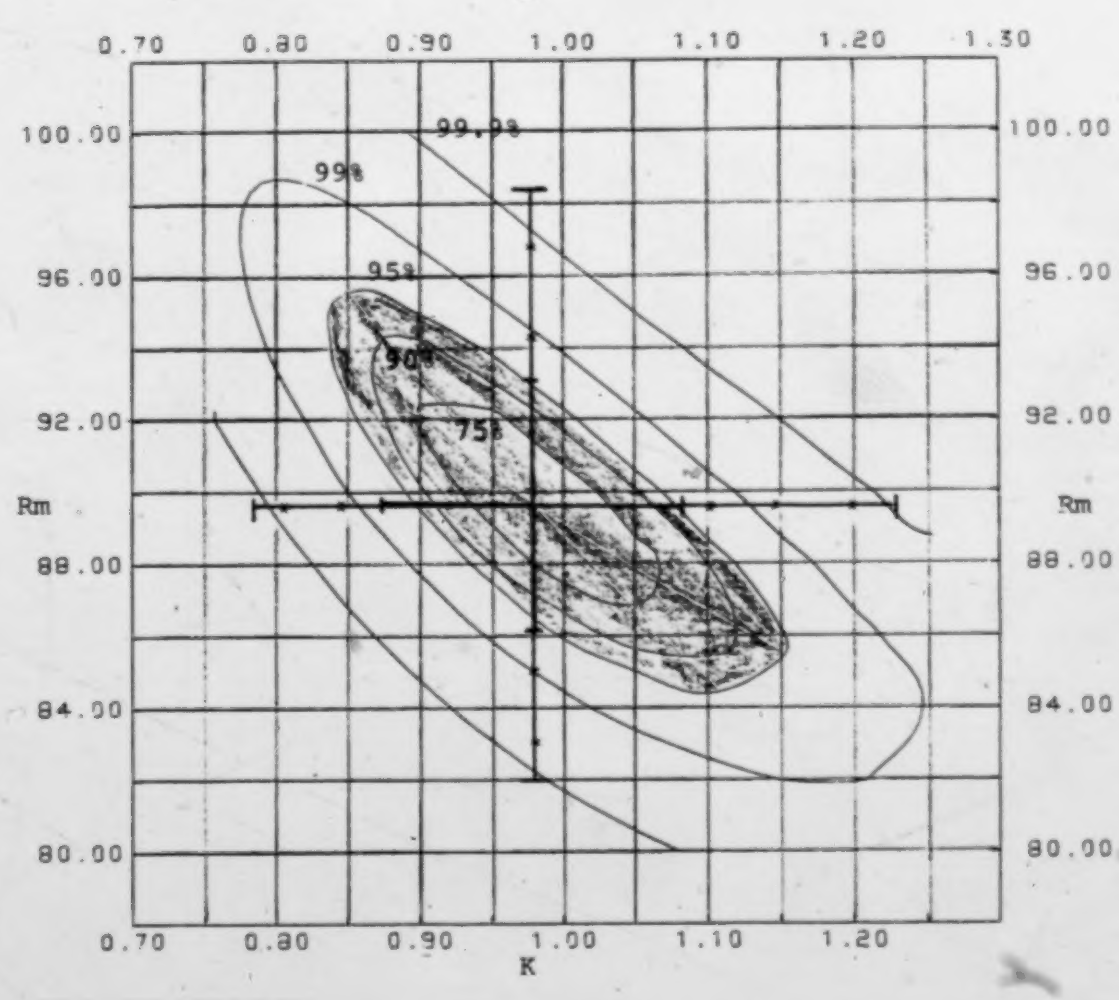
‘ Klimpel's procedure for obtaining the confidence limits follows the minimum "crease" of the elliptical "confidence surface".

Table 3.8 Comparision Of Confidence Limits

$$R=(100-\phi)(1-Exp(-Kft)+\phi(1-Exp(-Kst))$$

Parameter Values		95% Confidence Limits Methods	
		Monte-Carlo	Klimpel
Phi	30.80	±0.88	±8.63
Kf	1.22	±0.02	±0.22
Ks	0.105	±0.006	±0.053

The standard deviation of the data is 0.44%.



$R=R_m(1-\exp(-Kt))$

Confidence Limits Obtained From

├─┤ Monte-Carlo Method and Variance covariance matrix

├•┤ Klimpel's Method

Figure 3.10 An Illustration Of Typical Confidence Limits For The Two Parameter Model

Smith (42). However, a confidence limit can be obtained (a) by Kimpel's method, (b) by the Monte-Carlo method and (c) from the variance covariance matrix (analogous to multilinear regression procedures). Klimpel's method is based on lack of fit and not the statistical expectation approach and, as a result, gives incorrect estimates. The results from the Monte-Carlo method and the variance covariance matrix correspond with the confidence regions obtained by the method of Draper and Smith (42). Based upon this restricted study, the latter two methods are recommended for obtaining confidence limits.

4. COAL FLOTATION RESULTS AND DISCUSSION

4.1 PRESENTATION OF RESULTS

The raw data for the screening tests, the size fraction studies on the screening tests and the modelling tests are presented in Appendix I. Several programs were written in FORTRAN to process this data. The basic data processing and curve fitting program is presented as an example in Appendix II.

In order to minimize the length of this thesis, the results of only one (Test #1) of the experiments for the screening tests are summarized in Appendix III. This is the output of the data processing and curve fitting program. The output includes the experimental design information, material balances, simple recovery correlations and the modelling results for both the simple (Equation 2.7) and compound (Equation 2.8) first order recovery models.

The data for the individual size fractions for the screening tests are processed by a modified form of the (size composite) data processing program for the other tests. The results for Test #1 of this portion of the analysis are also presented in Appendix III.

The results of one (Test #1) of the experiments for the modelling tests are summarized on the output of the data processing program and presented in Appendix III.

4.2 ANALYSIS OF THE SCREENING TEST RESULTS

4.2.1 INTRODUCTION

A series of screening tests were performed to identify those factors which play a significant role in governing the flotation behaviour of the Gregg River Resources coal. This section deals with the results of the experimental design and data analysis in this phase of the thesis.

4.2.2 EXPERIMENTAL DESIGN FOR SCREENING TESTS

To study all possible factors in the experimental design was clearly impossible. In fact, within the time allotted for the project, it was determined that from 5 to 7 factors could be investigated. Keeping in mind the difficulty associated with controlling each factor, seven were ultimately chosen for investigation. The selection process involved discussions with Gregg River Resources personnel and the extraction of relevant information from the literature.

The screening series of tests was developed as a 1/4 fraction of a full 2 level, 7 factor, factorial design (i.e. a 2^{7-2} fractional factorial design ((28) and(29))). The factor levels were determined through discussions with Gregg River Resources personnel, through reading the related literature and through preliminary experimentation. Table 4.1 shows the 7 factors selected for study and their experimental levels as well as the experimental design in coded form. The coding relationship is:

$$\text{Coded Level} = \pm 1 = \left[\frac{\text{Level - Centre Point}}{\text{High Point - Centre Point}} \right] \quad \ldots(4.1)$$

The use of coded levels simplifies the regression analysis of the experimental results. The fact that the cross product terms are zero, i.e. $\Sigma\Sigma X_i X_j = 0$, gives rise to the term "orthogonal design" which is frequently used interchangably with the terminology above.

It is well known that flotation performance exhibits a dependency on the particle size and density distribution of the flotation feed solids. The independent control of either of these factors would have been prohibitive in terms of the added sample preparation time and hence they were excluded from the screening tests. That is, these tests deal exclusively with the size and density composite behaviour of the Gregg River Resources coal. However, some effort was made to identify particle size effects and the results of this work are presented in a later section.

The experimental design of Table 4.1 shows the coded levels of factors for the $2^5 = 32$ runs, plus 5 centre point runs. The latter were included to provide an independent measure of the error variance associated with a selected response. It is evident by inspection that, in so far as the first five factors are concerned ($X_1 \rightarrow X_5$), the design is the

Table 4.1 The Complete Experimental Design For The Screening Tests

OPERATING VARIABLES			Center points(0)	Min(-1)	Max(+1)
X1	=	air	5.0 l/min	3.0	7.0
X2	=	collector(fuel oil)	1.6 l/tonne	0.2	3.0
X3	=	frother(MIBC)	0.25 l/tonne	0.15	0.35
X4	=	conditioning time	3.0 min	1.0	5.0
X5	=	% solids in feed pulp	6.0 %	3.0	9.0
X6	=	impeller speed (power)	1100 rpm	950	1250
X7	=	pH	8.3	7.8	8.8

TEST	X1	X2	X3	X4	X5	X6	X7
1	-1	-1	-1	-1	-1	1	1
2	1	-1	-1	-1	-1	-1	1
3	-1	1	-1	-1	-1	-1	-1
4	1	1	-1	-1	-1	1	-1
5	-1	-1	1	-1	-1	-1	-1
6	1	-1	1	-1	-1	1	-1
7	-1	1	1	-1	-1	1	1
8	1	1	1	-1	-1	-1	1
9	-1	-1	-1	1	-1	-1	-1
10	1	-1	-1	1	-1	1	-1
11	-1	1	-1	1	-1	1	1
12	1	1	-1	1	-1	-1	1
13	-1	-1	1	1	-1	1	1
14	1	-1	1	1	-1	-1	1
15	-1	1	1	1	-1	-1	-1
16	1	1	1	1	-1	1	-1
17	-1	-1	-1	-1	1	1	-1
18	1	-1	-1	-1	1	-1	-1
19	-1	1	-1	-1	1	-1	1
20	1	1	-1	-1	1	1	1
21	-1	-1	1	-1	1	-1	1
22	1	-1	1	-1	1	1	1
23	-1	1	1	-1	1	1	-1
24	1	1	1	-1	1	-1	-1
25	-1	-1	-1	1	1	-1	1
26	1	-1	-1	1	1	1	1
27	-1	1	-1	1	1	1	-1
28	1	1	-1	1	1	-1	-1
29	-1	-1	1	1	1	1	-1
30	1	-1	1	1	1	-1	-1
31	-1	1	1	1	1	-1	1
32	1	1	1	1	1	1	1
CNTR1	0	0	0	0	0	0	0
CNTR2	0	0	0	0	0	0	0
CNTR3	0	0	0	0	0	0	0
CNTR4	0	0	0	0	0	0	0
CNTR5	0	0	0	0	0	0	0

standard full 2^5 factorial representation. Definition of the coded levels for factors 6 and 7 require the careful choice of "generators". For a $1/2^d$ fraction of a complete design, d generators must be selected. Moreover, they must be selected in a manner which maximizes the design "resolution". The latter simply means that the information available from the design is maximized. While a full factorial design permits the independent estimation of all possible main factor and interaction (linear) effects, fractional designs do not. That is, the effects can be "confounded". For this series of tests the generators chosen were:

$$X6 = X1\ X2\ X3\ X4 \qquad \ldots(4.2)$$

$$X7 = X2\ X3\ X4\ X5 \qquad \ldots(4.3)$$

giving rise to the defining relationships:

$$I = X1\ X2\ X3\ X4\ X6 \qquad \ldots(4.4)$$

$$I = X2\ X3\ X4\ X5\ X7 \qquad \ldots(4.5)$$

$$I = X1\ X5\ X6\ X7 \qquad \ldots(4.6)$$

Ignoring all interaction terms in the alias structure higher than second order (a common assumption) permits simplification. Under these conditions there is a relatively unambiguous relationship between the effects estimated from analysis of the 2^5 design and the associated terms given by the simplified alias structure. Although, by Equation 4.6, the resolution of the design is IV, there are only three occurrences of coupled two factor effects in the simplified alias structure. Choosing factors 6 and 7 to be those most unlikely to play a significant role in the flotation system will make the design pseudo resolution V. Table 4.2 presents the complete and simplified alias structures for the factorial design used in organizing the factor screening tests.

4.2.3 ANALYSIS OF SCREENING TEST RESULTS

The primary objective of the screening tests was to identify those factors which had a significant influence on the behaviour of the flotation system. Based upon the results of this phase of the project, the subsequent modelling test series was designed. A secondary objective of this phase was to provide additional data for modelling purposes, if necessary.

In order to estimate the significance of a factor in the flotation system, it is necessary to select some single valued function, either measured or calculated, which "rates" the flotation system performance. This quantity is referred to as the "response" and every experiment (or run) will have an associated response. The choice of the response

Table 4.2 Alias Structure Of The Experimental Design

2^{5}_{IV} effect	Alias Structure				Ignore all but one/two factor effects
BI	bI	1/4 b1567	1/4 b12346	1/4 b23457	bI
B1	b1	b567	b2346	b123457	b1
B2	b2	b12567	b1346	b3457	b2
B3	b3	b15367	b1246	b2457	b3
B4	b4	b14567	b1236	b23577	b4
B5	b5	b167	b123456	b2347	b5
B12	b12	b2567	b346	b13457	b12
B13	b13	b3567	b246	b12457	b13
B14	b14	b4567	b236	b12357	b14
B15	b15	b67	b23456	b12347	b15+b67
B23	b23	b123567	b146	b457	b23
B24	b24	b124567	b136	b357	b24
B25	b25	b1267	b13456	b347	b25
B34	b34	b134567	b126	b257	b34
B35	b35	b1367	b12456	b247	b35
B45	b45	b1467	b12356	b237	b45
B123	b123	b23567	b46	b1457	b46
B124	b124	b24567	b36	b1357	b36
B125	b125	b267	b3456	b1347	---
B134	b134	b34567	b26	b1257	b26
B135	b135	b367	b2456	b1247	---
B145	b145	b467	b2356	b1237	---
B234	b234	b1234567	b16	b57	b16+b57
B235	b235	b12367	b1456	b47	b47
B245	b245	b12467	b1356	b37	b37
B345	b345	b13467	b1256	b27	b27
B1234	b1234	b234567	b6	b157	b6
B1235	b1235	b2367	b456	b147	---
B1245	b1245	b2467	b356	b137	---
B1345	b1345	b3467	b256	b127	---
B2345	b2345	b123467	b156	b7	b7
B12345	b12345	b23467	b56	b17	b17+b56

B: coefficients estimated from fractional design
b: coefficients for complete linear response model

can effect which factors are determined to be significant, and it is therefore necessary to ensure that this quantity reflects what is judged to be most important in system behaviour.

The initial choice of the process response proved to be a poor one, in the sense that it was sometimes impossible to compute unambiguously. An alternate scheme for analyzing the data was developed. The results of both methods are summarized in the sections which follow.

4.2.4 ORIGINAL ANALYSIS SCHEME

The original proposed process response was the "flotation yield at some specified ash value." This choice was appealing because it has practical significance, unlike the more common technical efficiency indices. Computation of the response, Y, was theoretically straightforward once the recovery models for the organics, Ro(t), and the ash, Ra(t), had been derived from the data. Mathematically, Equation 4.7 must be solved by iteration for t^s, the value of time which satisfies the equality:

$$A_s = \frac{100FaRa(t^s)}{(100-Fa)Ro(t^s) + Ra(t^s)Fa} \qquad \ldots(4.7)$$

where: Fa =ash analysis of the flotation feed solids.
A_s =the ash quality specification.
Ro(t),Ra(t) =the recovery models for the organics and ash respectively.
t^s =batch flotation time.

The t^s value is then substituted into Equation 4.8 to compute the corresponding flotation yield.

$$Y = \frac{(100-Fa)Ro(t^s)+FaRa(t^s)}{100} \qquad \ldots(4.8)$$

The idea was to calculate the yield for several different levels of ash (7%, 8% & 9%), then, for each ash level, use linear regression analysis to determine the important factors. This would not only identify important factors, but it would show how they changed as a function of the flotation target ash quality.

Unfortunately, the results of this analysis proved to be inconclusive. The problems arise from the fact that over the range of the factor levels studied, three possible solution conditions for a particular run at a particular ash specification can be obtained, namely:

a) Even as $t \to \infty$, Equation 4.7 cannot be solved because the right hand side is always $<A_s$.

b) Equation 4.7 can be solved for t^s, and a yield can be calculated.

c) Even as $t \to 0$, Equation 4.7 cannot be solved because the right hand side is always $>A_s$.

Cases (a) and (c) present special problems in assigning a response. It was argued that, in the absence of an extrapolation methodology or a penalty fuction, case (a) would report $Y(t \to \infty)$ and case (c) would report $Y=0$. This creates an very highly irregular response surface, an undesirable condition for linear regression analysis. In fact, in performing the standard factorial design regression analysis it was observed that some of the factors which were expected to be insignificant were identified as important. As a result, this method of analysis was discontinued, however, it is suggested that for future work, it may be worthwhile to investigate this alternative[1]. To illustrate this discussion the results of the response calculation for the 8% ash specification are presented in Table 4.3.

4.2.5 THE ALTERNATIVE ANALYSIS SCHEME

Since the method above proved to be unreliable in the factor identification step, an alternative strategy had to be developed. Reflecting on the means by which the experimental data was reduced, it was argued that the model parameters must carry all of the process information, assuming that there is no lack of fit. ϕ conveys the equilibrium behaviour and Kf and Ks convey the kinetic behaviour. The results of the screening studies have been extracted from the output of the data processing program and are summarized for each slurry component in Tables 4.4 through 4.6. Included with the parameters is the residual mean sum of squares (RMS; Equation 3.2), which is a measure of the goodness of fit (29). To check for lack of fit in the

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[1] Probably the the best reponse would be the overall plant yield at the contract ash specification. This would require washability data and models for the dense medium circuits together with a model of the automedium cyclone circuit and the residence time distribution of the flotation cell banks.

Table 4.3 Estimated Flotation Yield At An Ash Specification Of 8%

TEST#	TIME	ASH	YIELD
1	70.117 MIN	8.000	84.062 *
2	21.528 MIN	8.000	89.905 *
3	19.044 MIN	8.000	69.232 *
4	11.286 MIN	8.000	75.404 *
5	14.735 MIN	8.000	83.371 *
6	1.222 MIN	8.000	68.649
7	8.997 MIN	8.000	73.634
8	1.267 MIN	8.000	78.098
9	100.000 MIN	7.663	87.184 *
10	66.114 MIN	8.000	81.853 *
11	20.277 MIN	8.000	83.273 *
12	12.226 MIN	8.000	87.121 *
13	50.513 MIN	8.000	91.963 *
14	17.201 MIN	8.000	93.469 *
15	11.097 MIN	8.000	88.125 *
16	0.417 MIN	8.000	41.485
17	4.444 MIN	8.000	84.716
18	6.483 MIN	8.000	86.629
19	2.040 MIN	8.000	72.449
20	0.001 MIN	0.0	0.0
21	50.000 MIN	7.923	87.461 *
22	0.484 MIN	8.000	65.923
23	0.001 MIN	0.0	0.0
24	0.003 MIN	8.000	0.354
25	50.000 MIN	7.327	90.729 *
26	1.127 MIN	8.000	79.837
27	0.001 MIN	0.0	0.0
28	0.001 MIN	0.0	0.0
29	0.598 MIN	8.000	48.548
30	0.730 MIN	8.000	64.452
31	1.768 MIN	8.000	73.529
32	0.001 MIN	0.0	0.0
CNTR			
1	0.810 MIN	8.000	55.931
2	0.593 MIN	8.000	46.667
3	0.003 MIN	8.000	0.269
4	0.769 MIN	8.000	49.566
5	0.733 MIN	8.000	50.409

* Note that the time of flotation was not physically possible. But theoretically, the target ash was reached after a very long period of time. The maximum time limit was 100 min.. For some, the target ash was not reached even after 100 min.

Table 4.4 Compound First Order Model Parameter Estimates For The Organic Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	54.91	1.498	0.021	0.12
2	41.44	2.078	0.088	4.59
3	57.14	2.756	0.038	1.10
4	53.23	2.183	0.082	9.05
5	33.83	2.363	0.063	1.42
6	22.61	1.769	0.116	4.96
7	47.15	4.156	0.077	0.21
8	23.36	2.599	0.296	2.61
9	71.35	1.355	0.021	0.58
10	63.27	0.879	0.022	1.90
11	35.22	1.773	0.047	0.37
12	58.98	3.928	0.153	5.59
13	29.63	1.510	0.038	12.74
14	26.37	1.673	0.129	3.94
15	61.73	2.889	0.177	4.74
16	35.82	2.402	0.176	2.99
17	12.04	1.250	0.013	0.35
18	13.26	1.310	0.049	0.75
19	15.95	1.108	0.008	29.42
20	8.98	1.984	0.186	1.39
21	8.85	0.627	0.000	16.78 *
22	33.41	4.430	0.724	3.81
23	15.72	1.350	0.063	0.50
24	17.97	1.723	0.268	0.41
25	5.10	0.820	0.000	15.75 *
26	13.39	2.470	0.148	1.99
27	4.57	1.066	0.000	0.17 *
28	7.58	1.229	0.116	0.12
29	19.67	1.523	0.221	1.70
30	16.34	2.014	0.250	7.03
31	8.31	1.020	0.000	4.65 *
32	1.83	1.471	0.000	5.58 *
CNTR#				
1	8.88	1.241	0.063	5.25
2	8.24	1.270	0.010	4.78
3	8.39	1.222	0.012	6.06
4	7.75	1.056	0.056	2.93
5	4.64	1.089	0.000	0.25 *

* Defaulted to simple first order model.

Table 4.5 Compound First Order Model Parameter Estimates For The Ash Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	83.92	1.578	0.010	0.03
2	71.25	1.746	0.028	1.43
3	78.18	2.505	0.020	1.03
4	73.48	1.820	0.034	3.92
5	62.30	2.101	0.027	0.67
6	43.49	1.324	0.036	3.28
7	67.10	3.820	0.037	0.38
8	40.89	1.699	0.050	2.06
9	87.26	0.961	0.007	0.02
10	84.73	0.596	0.010	0.56
11	61.96	1.709	0.020	0.21
12	75.80	2.821	0.050	6.39
13	66.55	1.357	0.012	2.62
14	56.34	1.251	0.028	1.55
15	74.17	2.187	0.062	3.10
16	51.27	2.006	0.058	2.99
17	43.92	1.115	0.011	0.15
18	46.16	1.094	0.018	0.14
19	44.39	0.950	0.019	10.65
20	25.71	1.660	0.025	0.76
21	40.57	0.489	0.000	4.06 *
22	31.69	2.155	0.060	8.73
23	34.82	1.336	0.039	0.30
24	31.55	1.389	0.264	1.19
25	41.69	0.689	0.000	4.33 *
26	41.03	1.953	0.033	2.01
27	22.92	0.973	0.006	0.16
28	29.12	1.092	0.021	0.17
29	38.03	1.278	0.038	0.66
30	36.58	1.502	0.074	5.25
31	37.16	0.896	0.007	3.03
32	19.43	1.425	0.038	6.34
CNTR#				
1	34.16	1.056	0.028	1.24
2	32.60	1.084	0.003	1.34
3	37.86	1.077	0.022	2.05
4	33.96	0.920	0.024	1.54
5	33.40	0.985	0.022	0.30

* Defaulted to simple first order model.

Table 4.6 Compound First Order Model Parameter Estimates For The Water Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	97.22	2.204	0.012	0.05
2	94.62	0.963	0.018	0.23
3	83.44	0.231	0.000	0.27 *
4	97.19	2.812	0.015	0.09
5	93.15	0.784	0.008	0.14
6	91.62	0.870	0.016	0.30
7	90.63	0.894	0.015	0.03
8	91.48	1.227	0.014	0.05
9	87.11	0.294	0.000	0.22 *
10	74.06	0.113	0.000	0.63 *
11	94.36	1.824	0.013	0.09
12	92.57	0.850	0.014	0.04
13	92.51	0.825	0.011	0.15
14	93.32	1.172	0.015	0.21
15	92.65	0.645	0.006	0.00
16	94.12	2.373	0.010	0.01
17	84.56	1.675	0.015	0.21
18	84.39	1.384	0.014	0.11
19	86.95	1.173	0.019	0.57
20	78.97	2.119	0.012	0.37
21	84.22	0.647	0.019	0.79
22	78.50	2.270	0.016	1.81
23	85.04	1.723	0.020	0.80
24	79.11	1.243	0.011	1.34
25	80.82	0.948	0.006	0.70
26	83.00	2.225	0.019	1.19
27	83.67	1.196	0.019	3.16
28	79.20	1.341	0.006	0.03
29	81.85	1.395	0.018	0.22
30	84.24	2.204	0.026	0.60
31	81.69	0.938	0.014	0.18
32	82.99	2.188	0.022	0.72
CNTR#				
1	90.82	1.508	0.021	0.25
2	95.85	3.403	0.025	2.01
3	92.15	1.841	0.023	0.01
4	91.55	1.513	0.019	0.55
5	92.88	2.356	0.023	0.21

* Defaulted to simple first order model.

model the following procedure was employed.

Using the centre point runs the recovery variances were computed for each time increment and for each component. Variance tests over time for a particular component indicated homogeneity which allowed a pooled variance estimate. The results of this exercise were:

$s^2(\text{org.})=3.24\%^2$

$s^2(\text{ash})=3.16\%^2$

$s^2(H_2O)=1.59\%^2$

with 20 degrees of freedom in all cases. s^2 is referred to as the standard error of estimate and an unbiased estimate of the variance (Miller and Freund (38)). For a particular data set, if the model exhibits lack of fit, then the estimate of s^2, i.e. RMS, will differ significantly from the value reported above. This is true provided that the s^2 estimates derived from the centre point runs are valid over all conditions, an assumption which is made in the absence of evidence to the contrary. The RMS is an estimate of s^2, and the critical RMS values are equal to product values of s^2 and the appropriate "F" statistics. Since the RMS value can have either 2 or 3 degrees of freedom depending upon the parent model (3 or 2 parameter-5 increment collection sequence), the critical "F" statistics for testing lack of fit are $F_{2,20,.05}=3.49$ and $F_{3,20,.05}=3.10$ and the critical RMS values are shown in Table 4.7. RMS values in the Tables 4.4 to 4.6 which exceed these critical values indicate lack of fit for the model on that particular data set. Comparing

Table 4.7 The Critical RMS Values

Component	Critical RMS Value	
	3 Param.	2 Param.
Organics	11.31	10.04
Ash	11.03	9.08
Water	5.55	4.93

the critical RMS values to the data in Tables 4.4 through 4.6 indicate that lack of fit is a rare occurrence and, for the purposes of this phase of the thesis, it will be assumed that the compound first order model is an accurate representation of the physical process[*]. Implicit in this conclusion is that the contributions to the RMS are randomly distributed in time. This might be questioned although it is felt to be a reasonable assumption.

Accepting the model form permits the correlation of the parameters with the factors. Significant correlations imply important factors. The procedure is to examine the complete linear response model, i.e. 2^5-1 independent variables, and determine which of them make a significant contribution to explaining the variance in the response. (The independent variables are all of those terms in the left most column of Table 4.2 excluding the intercept term, I.) The regression analysis was done using both an unweighted and a weighted least squares objective function (Box, Hunter and Hunter (39)).

4.2.5.1 IDENTIFICATION OF IMPORTANT FACTORS THROUGH UNWEIGHTED REGRESSION ANALYSIS

The unweighted regression analysis is the standard form of analysing the results from an orthogonally designed experiment ((28), (29) and (39)). The assumption is that the variance of the response is homogeneous over all test conditions. To analyse the 2^5 design, the BMDP statistical package (37) and a computer program written by Flintoff[1] at the University of Alberta was used.

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[*] In those cases where lack of fit was evident, the behaviour of the flotation system was observed to be unusual. Generally the froth was observed to heavily laden with particles and rather immobile.

Tables 4.8 through 4.16 summarize the results of this analysis. In each table, the summary of the program output is divided into two sections. The first shows the regression coefficients and associated sum of squares for the terms in the conventional form and the second performs the stepwise regression ordering. In the latter case, an "F to enter" statistic is computed for each term, assuming all those above it are already in the regression. Thus, to obtain the stepwise regression solution one simply moves down the appropriate column until the calculated "F" statistic is less than the tabulated value. All of the terms above this point are significant and would be included in the linear response model.

The standard method of determining the significance of the candidate terms in the regression is to compare the calculated sum of squares associated with each term

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[1] The computer program written by B. C. Flintoff is written in HP-9825-A language. It is written to analyse any 2^n design, requiring only that the user enter the response data in the standard form. This program is presented in Appendix IV. A feature of the program is that it sorts the potential terms in the regression equation into an order corresponding to their level of correlation with the response. This is analogous to the procedure involved in obtaining a forward stepwise regression solution to the problem.

Table 4.8 Regression Analysis: Kf For The Organic Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	1.9144	117.275					
1	0.2229	1.590	25	5.369	7.30	30	0.1956
2	0.1913	1.171	5	3.426	5.33	29	0.3205
3	0.1806	1.043	12345	2.655	4.65	28	0.4172
4	-0.1596	0.815	15	2.312	4.56	27	0.5015
5	-0.3272	3.426	1	1.590	3.42	26	0.5594
12	-0.1319	0.557	135	1.355	3.15	25	0.6088
13	-0.0577	0.106	2	1.171	2.94	24	0.6514
14	0.0374	0.045	123	1.104	3.00	23	0.6917
15	0.2688	2.312	145	1.092	3.26	22	0.7314
23	-0.0850	0.231	3	1.043	3.46	21	0.7695
24	0.0329	0.035	124	0.857	3.14	20	0.8007
25	-0.4096	5.369	2345	0.825	3.37	19	0.8308
34	-0.1226	0.481	4	0.815	3.83	18	0.8605
35	0.0020	0.000	12	0.557	2.89	17	0.8808
45	0.0241	0.019	1345	0.554	3.26	16	0.9010
123	-0.1858	1.104	125	0.515	3.51	15	0.9197
124	0.1637	0.857	134	0.503	4.14	14	0.9380
125	-0.1269	0.515	34	0.481	5.12	13	0.9556
134	-0.1253	0.503	1245	0.293	3.80	12	0.9663
135	0.2058	1.355	23	0.231	3.66	11	0.9747
145	-0.1847	1.092	235	0.182	3.55	10	0.9313
234	-0.0065	0.001	245	0.156	3.92	9	0.9870
235	-0.0754	0.182	1234	0.147	5.59	8	0.9923
245	-0.0698	0.156	13	0.106	7.18	7	0.9962
345	-0.0046	0.001	14	0.045	4.53	6	0.9978
1234	0.0678	0.147	24	0.035	7.10	5	0.9991
1235	0.0108	0.004	45	0.019	12.55	4	0.9998
1245	-0.0958	0.293	1235	0.004	5.19	3	0.9999
1345	-0.1316	0.554	234	0.001	3.33	2	1.0000
2345	0.1606	0.825	345	0.001	5.35	1	1.0000
12345	0.2881	2.655	35	0.000	0.00	0	1.0000

Table 4.9 Regression Analysis: Kf For The Ash Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	1.5462	72.499					
1	0.0497	0.079	5	2.811	7.22	30	0.1940
2	0.2218	1.575	25	2.105	6.38	29	0.3393
3	0.0923	0.273	15	1.757	6.29	28	0.4606
4	-0.1277	0.521	2	1.575	6.81	27	0.5692
5	-0.2964	2.811	12345	0.737	3.48	26	0.6201
12	-0.0787	0.198	145	0.537	2.70	25	0.6572
13	-0.0942	0.284	4	0.521	2.81	24	0.6931
14	0.1126	0.406	135	0.455	2.62	23	0.7245
15	0.2343	1.757	124	0.414	2.55	22	0.7531
23	-0.0155	0.008	14	0.406	2.69	21	0.7811
24	-0.0017	0.000	1245	0.395	2.85	20	0.8084
25	-0.2565	2.105	45	0.345	2.70	19	0.8323
34	-0.0230	0.017	13	0.284	2.38	18	0.8519
35	-0.0333	0.035	1345	0.283	2.58	17	0.8714
45	0.1039	0.345	245	0.278	2.80	16	0.8905
123	-0.0918	0.270	3	0.273	3.11	15	0.9093
124	0.1138	0.414	123	0.270	3.61	14	0.9279
125	-0.0290	0.027	2345	0.266	4.45	13	0.9463
134	-0.0098	0.003	1234	0.233	5.14	12	0.9624
135	0.1192	0.455	12	0.198	6.28	11	0.9761
145	-0.1296	0.537	234	0.130	6.03	10	0.9851
234	-0.0638	0.130	1	0.079	5.17	9	0.9905
235	0.0029	0.000	1235	0.041	3.44	8	0.9934
245	-0.0932	0.278	35	0.035	4.09	7	0.9958
345	0.0133	0.006	125	0.027	4.77	6	0.9977
1234	0.0854	0.233	34	0.017	5.05	5	0.9988
1235	0.0359	0.041	23	0.008	3.40	4	0.9994
1245	-0.1112	0.395	345	0.006	4.94	3	0.9993
1345	-0.0940	0.283	134	0.003	16.78	2	1.0000
2345	0.0912	0.266	235	0.000	2.86	1	1.0000
12345	0.1517	0.737	24	0.000	0.00	0	1.0000

Table 4.10 Regression Analysis: Kf For The Water Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	1.3359	57.106					
1	0.2488	1.980	1234	3.551	9.49	30	0.2402
2	0.0877	0.246	1	1.980	6.21	29	0.3742
3	0.0014	0.000	5	1.355	4.81	28	0.4659
4	-0.0528	0.089	125	1.207	4.87	27	0.5476
5	0.2058	1.355	34	1.069	4.95	26	0.6199
12	0.0968	0.300	25	0.620	3.10	25	0.6619
13	0.1074	0.369	245	0.587	3.19	24	0.7016
14	0.0264	0.022	134	0.578	3.47	23	0.7407
15	0.0813	0.212	1345	0.500	3.30	22	0.7746
23	-0.0211	0.014	1245	0.417	3.01	21	0.8028
24	0.0486	0.076	13	0.369	2.90	20	0.8277
25	-0.1393	0.620	124	0.342	2.95	19	0.8509
34	0.1828	1.069	123	0.314	2.99	18	0.8721
35	0.0327	0.034	12	0.300	3.21	17	0.8924
45	0.0653	0.136	345	0.261	3.14	16	0.9100
123	-0.0991	0.314	2	0.246	3.41	15	0.9267
124	-0.1034	0.342	15	0.212	3.40	14	0.9410
125	-0.1943	1.207	145	0.199	3.85	13	0.9545
134	0.1344	0.578	2345	0.149	3.42	12	0.9646
135	-0.0369	0.044	45	0.136	3.87	11	0.9738
145	0.0789	0.199	4	0.089	2.99	10	0.9798
234	-0.0465	0.069	24	0.076	3.06	9	0.9849
235	0.0199	0.013	234	0.069	3.61	8	0.9896
245	-0.1354	0.587	135	0.044	2.79	7	0.9926
345	-0.0903	0.261	35	0.034	2.72	6	0.9949
1234	0.3331	3.551	14	0.022	2.11	5	0.9964
1235	-0.0115	0.004	12345	0.022	2.82	4	0.9979
1245	0.1142	0.417	23	0.014	2.52	3	0.9989
1345	-0.1250	0.500	235	0.013	5.89	2	0.9997
2345	0.0683	0.149	1235	0.004	69.95	1	1.0000
12345	-0.0262	0.022	3	0.000	0.00	0	1.0000

Table 4.11 Regression Analysis: Ks For The Organic Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	0.1122	0.403					
1	0.0630	0.127	1	0.127	7.80	30	0.2064
2	-0.0068	0.001	3	0.081	5.73	29	0.3374
3	0.0502	0.081	25	0.054	4.25	28	0.4248
4	-0.0186	0.011	235	0.043	3.75	27	0.4950
5	0.0157	0.008	134	0.040	3.81	26	0.5596
12	-0.0088	0.002	12345	0.034	3.64	25	0.6156
13	0.0195	0.012	14	0.034	3.96	24	0.6701
14	-0.0324	0.034	15	0.023	2.92	23	0.7073
15	0.0268	0.023	1345	0.019	2.54	22	0.7376
23	-0.0235	0.018	23	0.018	2.58	21	0.7663
24	-0.0033	0.000	123	0.014	2.13	20	0.7888
25	-0.0410	0.054	145	0.014	2.25	19	0.8112
34	-0.0199	0.013	1235	0.013	2.31	18	0.8326
35	0.0127	0.005	34	0.013	2.40	17	0.8533
45	-0.0174	0.010	13	0.012	2.49	16	0.8731
123	-0.0208	0.014	4	0.011	2.47	15	0.8910
124	0.0058	0.001	125	0.011	2.75	14	0.9089
125	-0.0186	0.011	45	0.010	2.73	13	0.9247
134	-0.0353	0.040	345	0.009	3.02	12	0.9399
135	0.0105	0.004	5	0.008	2.97	11	0.9527
145	-0.0208	0.014	1245	0.006	2.71	10	0.9628
234	-0.0021	0.000	35	0.005	2.61	9	0.9711
235	-0.0368	0.043	245	0.005	2.72	8	0.9785
245	-0.0119	0.005	135	0.004	2.54	7	0.9842
345	-0.0171	0.009	12	0.002	2.06	6	0.9882
1234	0.0087	0.002	1234	0.002	2.50	5	0.9922
1235	-0.0203	0.013	2345	0.002	2.38	4	0.9951
1245	0.0139	0.006	2	0.001	2.80	3	0.9975
1345	-0.0241	0.019	124	0.001	4.48	2	0.9992
2345	0.0075	0.002	24	0.000	2.34	1	0.9998
12345	0.0328	0.034	234	0.000	0.00	0	1.0000

Table 4.12 Regression Analysis: Ks For The Ash Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	0.0294	0.028					
1	0.0098	0.003	3	0.003	10.24	30	0.2545
2	0.0049	0.001	1	0.003	14.20	29	0.4995
3	0.0099	0.003	245	0.002	9.45	28	0.6258
4	-0.0004	0.000	25	0.001	8.42	27	0.7148
5	-0.0011	0.000	2	0.001	7.35	26	0.7776
12	-0.0016	0.000	135	0.000	5.06	25	0.8151
13	0.0019	0.000	15	0.000	5.16	24	0.8478
14	0.0003	0.000	2345	0.000	5.50	23	0.8771
15	0.0036	0.000	12345	0.000	5.96	22	0.9033
23	0.0001	0.000	234	0.000	3.07	21	0.9157
24	-0.0012	0.000	235	0.000	3.20	20	0.9273
25	-0.0059	0.001	125	0.000	3.37	19	0.9383
34	0.0007	0.000	134	0.000	3.61	18	0.9486
35	0.0018	0.000	13	0.000	3.64	17	0.9576
45	-0.0008	0.000	123	0.000	4.35	16	0.9667
123	-0.0019	0.000	35	0.000	4.66	15	0.9746
124	0.0006	0.000	12	0.000	5.12	14	0.9814
125	-0.0021	0.000	1345	0.000	4.07	13	0.9858
134	-0.0020	0.000	24	0.000	4.14	12	0.9895
135	0.0038	0.000	5	0.000	4.94	11	0.9927
145	0.0008	0.000	145	0.000	3.06	10	0.9944
234	-0.0022	0.000	45	0.000	3.17	9	0.9959
235	-0.0021	0.000	34	0.000	3.36	8	0.9971
245	-0.0070	0.002	124	0.000	3.72	7	0.9981
345	-0.0003	0.000	1235	0.000	4.54	6	0.9989
1234	-0.0003	0.000	4	0.000	4.22	5	0.9994
1235	0.0006	0.000	14	0.000	1.52	4	0.9996
1245	0.0002	0.000	345	0.000	1.85	3	0.9997
1345	-0.0013	0.000	1234	0.000	3.20	2	0.9999
2345	-0.0034	0.000	1245	0.000	9.00	1	1.0000
12345	0.0032	0.000	23	0.000	0.00	0	1.0000

Table 4.13 Regression Analysis: Ks For The Water Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	0.0132	0.006					
1	0.0010	0.000	5	0.000	7.58	30	0.2017
2	-0.0001	0.000	3	0.000	3.62	29	0.2903
3	0.0018	0.000	234	0.000	4.00	28	0.3789
4	-0.0008	0.000	145	0.000	3.82	27	0.4559
5	0.0028	0.000	2345	0.000	4.29	26	0.5329
12	-0.0012	0.000	1235	0.000	3.10	25	0.5845
13	0.0002	0.000	1234	0.000	3.07	24	0.6316
14	0.0005	0.000	15	0.000	3.02	23	0.6744
15	-0.0013	0.000	134	0.000	3.33	22	0.7172
23	-0.0010	0.000	125	0.000	3.33	21	0.7559
24	0.0007	0.000	12	0.000	3.33	20	0.7907
25	-0.0005	0.000	1	0.000	2.90	19	0.8185
34	0.0010	0.000	45	0.000	3.24	18	0.8462
35	0.0004	0.000	245	0.000	3.74	17	0.8739
45	0.0010	0.000	23	0.000	3.85	16	0.8984
123	0.0002	0.000	34	0.000	4.76	15	0.9228
124	-0.0004	0.000	4	0.000	3.64	14	0.9387
125	-0.0012	0.000	24	0.000	2.92	13	0.9500
134	0.0013	0.000	135	0.000	2.70	12	0.9592
135	0.0006	0.000	14	0.000	2.42	11	0.9665
145	0.0017	0.000	25	0.000	2.82	10	0.9739
234	-0.0018	0.000	345	0.000	3.53	9	0.9812
235	0.0001	0.000	1245	0.000	3.52	8	0.9870
245	-0.0010	0.000	35	0.000	3.45	7	0.9913
345	0.0005	0.000	124	0.000	5.83	6	0.9956
1234	0.0013	0.000	12345	0.000	4.35	5	0.9976
1235	0.0014	0.000	123	0.000	4.45	4	0.9989
1245	-0.0005	0.000	13	0.000	3.95	3	0.9995
1345	-0.0000	0.000	2	0.000	1.80	2	0.9997
2345	0.0017	0.000	235	0.000	9.00	1	1.0000
12345	0.0003	0.000	1345	0.000	0.00	0	1.0000

Table 4.14 Regression Analysis: ϕ For The Organic Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	28.7191	26393.106					
1	-1.3541	58.672	5	8226.276	54.23	30	0.6441
2	-0.3728	4.448	35	1203.810	10.44	29	0.7383
3	-3.5566	404.772	3	404.772	3.86	28	0.7700
4	-0.0216	0.015	235	376.408	3.97	27	0.7995
5	-16.0334	8226.276	45	300.677	3.16	26	0.8230
12	-1.0234	33.518	2345	271.736	3.42	25	0.8443
13	-1.5947	81.377	123	245.367	3.38	24	0.8635
14	0.6041	11.677	15	244.371	3.75	23	0.8826
15	2.7634	244.371	134	204.475	3.47	22	0.8936
23	1.6966	92.106	135	170.801	3.19	21	0.9120
24	-1.5697	78.845	234	155.717	3.22	20	0.9242
25	-2.1991	154.748	25	154.748	3.61	19	0.9363
34	-0.1784	1.019	1235	130.532	3.44	18	0.9465
35	6.1334	1203.810	145	106.836	3.15	17	0.9549
45	-3.0653	300.677	23	92.106	3.05	16	0.9621
123	-2.7691	245.367	13	81.377	3.03	15	0.9685
124	1.0709	36.701	24	78.845	3.41	14	0.9747
125	-1.4097	63.591	12345	73.842	3.84	13	0.9804
134	-2.5278	204.475	125	63.591	4.10	12	0.9854
135	2.3103	170.801	1	58.672	5.06	11	0.9900
145	-1.8272	106.836	124	36.701	4.04	10	0.9929
234	2.2059	155.717	12	33.518	5.26	9	0.9965
235	-3.4297	376.408	1345	21.863	4.93	8	0.9972
245	0.1153	0.426	14	11.677	3.43	7	0.9981
345	-0.4597	6.762	1234	8.110	3.10	6	0.9988
1234	-0.5034	8.110	345	6.762	3.73	5	0.9993
1235	2.0197	130.532	2	4.448	3.96	4	0.9996
1245	0.3084	3.044	1245	3.044	6.26	3	0.9999
1345	-0.8266	21.863	34	1.019	4.63	2	1.0000
2345	-2.9141	271.736	245	0.426	28.60	1	1.0000
12345	1.5191	73.842	4	0.015	0.00	0	1.0000

Table 4.15 Regression Analysis: ϕ For The Ash Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	51.3581	84405.024					
1	-3.9506	499.438	5	8253.555	63.22	30	0.6782
2	-3.3613	361.536	3	1007.781	10.05	29	0.7610
3	-5.6119	1007.781	35	522.938	6.14	28	0.8039
4	0.1444	0.667	1	499.438	7.15	27	0.8450
5	-16.0600	8253.555	2	361.536	6.16	26	0.8747
12	-0.6400	13.107	13	267.383	5.31	25	0.8966
13	-2.8906	267.383	45	154.528	3.36	24	0.9093
14	1.7356	96.397	23	149.818	3.61	23	0.9217
15	1.3113	55.020	1234	125.453	3.33	22	0.9320
23	2.1638	149.818	14	96.397	2.77	21	0.9399
24	-1.6625	88.445	24	88.445	2.75	20	0.9472
25	-1.2994	54.028	135	83.334	2.83	19	0.9540
34	1.5506	76.942	34	76.942	2.87	18	0.9603
35	4.0425	522.938	1235	71.461	2.95	17	0.9662
45	-2.1975	154.528	134	65.494	3.03	16	0.9716
123	-1.2825	52.634	15	55.020	2.84	15	0.9761
124	0.2813	2.531	25	54.028	3.19	14	0.9805
125	-0.9056	26.245	123	52.634	3.71	13	0.9849
134	-1.4306	65.494	12345	40.455	3.38	12	0.9882
135	1.6138	83.334	2345	33.008	3.28	11	0.9909
145	-0.8013	20.544	234	27.454	3.29	10	0.9932
234	0.9263	27.454	125	26.245	4.14	9	0.9953
235	-0.4919	7.742	145	20.544	4.50	8	0.9970
245	0.2356	1.777	12	13.107	3.91	7	0.9981
345	-0.4263	5.814	235	7.742	2.96	6	0.9987
1234	-1.9800	125.453	345	5.814	2.94	5	0.9992
1235	1.4944	71.461	1345	4.682	3.59	4	0.9996
1245	0.0869	0.242	124	2.531	2.83	3	0.9998
1345	-0.3825	4.682	245	1.777	3.91	2	0.9999
2345	-1.0156	33.008	4	0.667	2.76	1	1.0000
12345	-1.1244	40.455	1245	0.242	0.00	0	1.0000

Table 4.16 Regression Analysis: ϕ For The Water Component

Linear Regression			Stepwise Linear Regression				
Factors	Coeff.	SSQ	Factors	SSQ	F entry	D.F.	r^2
I	86.8516	241382.205					
1	-0.6403	13.120	5	619.960	31.84	30	0.5148
2	0.2772	2.459	125	67.309	3.78	29	0.5707
3	0.4684	7.022	145	61.134	3.76	28	0.6215
4	-0.7166	16.431	34	55.572	3.75	27	0.6677
5	-4.4016	619.960	245	53.380	4.00	26	0.7120
12	0.4653	6.929	24	49.526	4.16	25	0.7531
13	0.2428	1.887	134	46.152	4.41	24	0.7915
14	-0.0572	0.105	234	45.816	5.13	23	0.8295
15	-0.5097	8.313	1235	44.486	6.09	22	0.8664
23	-0.3834	4.705	2345	25.294	3.92	21	0.8874
24	1.2441	49.526	4	16.431	2.76	20	0.9011
25	-0.5247	8.810	35	16.288	3.01	19	0.9146
34	1.3178	55.572	1	13.120	2.63	18	0.9255
35	-0.7134	16.288	235	12.840	2.84	17	0.9362
45	0.4491	6.453	1345	11.846	2.92	16	0.9460
123	-0.3566	4.068	345	10.136	2.77	15	0.9544
124	-0.2041	1.333	25	8.810	2.68	14	0.9617
125	-1.4503	67.309	15	8.313	2.86	13	0.9687
134	1.2009	46.152	3	7.022	2.74	12	0.9745
135	-0.0878	0.247	12	6.929	3.20	11	0.9802
145	1.3822	61.134	45	6.453	3.72	10	0.9856
234	-1.1966	45.816	23	4.705	3.35	9	0.9895
235	0.6334	12.840	123	4.068	3.80	8	0.9929
245	-1.2916	53.380	2	2.459	2.82	7	0.9949
345	-0.5628	10.136	13	1.887	2.68	6	0.9965
1234	0.0416	0.055	1245	1.571	2.96	5	0.9978
1235	1.1791	44.486	124	1.333	4.03	4	0.9989
1245	0.2216	1.571	12345	0.915	6.75	3	0.9997
1345	-0.6084	11.846	135	0.247	3.09	2	0.9999
2345	0.8891	25.294	14	0.105	1.89	1	1.0000
12345	-0.1691	0.915	1234	0.055	0.00	0	1.0000

to some independent estimate of the error variance of the response. If the term is not significantly correlated to the response then the calculated sum of squares will simply be an estimate of the error variance. The comparison can be made using the standard "F" test. The independent error variance is usually obtained either from additional runs either at centre point factor levels, or replicates of particular tests in the design. Each approach has its advantages and disadvantages. In this project centre point repeat runs were used. The parameter estimates for the centre point runs were used to compute the error variance values[10]. Using a tabulated value of $F_{1,4,.05}$=7.71, the variance values were multiplied to yield a critical sum of squares level for each parameter for each component, which is shown in Table 4.17.

It is clear by inspection of the sum of squares column in the stepwise regression portion of Tables 4.8 through 4.16 that a large number of terms would be retained in the linear model using the standard approach. Moreover, in many cases, those terms which are expected to estimate no effect, i.e. error variance (see right most column in Table 4.2), appeared in the final response model (e.g. 125, 135, 145,...). This observation, coupled with the non-linearity of the

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[10] It is interesting to note that these values agreed quite well with those obtained in the Monte Carlo simulation exercise of section 3.5.2.1.

Table 4.17 Critical Sum Of Squares Levels

Component	Critical Sum Of Squares Levels		
	Phi	Kf	Ks
Organics	22.07	0.071	0.006
Ash	31.74	0.028	0.008
Water	42.79	4.861	3.5*E-5

response surface evidenced by the disparity in the estimated mean parameter values between the centre point runs and the results of the regression analysis led the author to abandon the standard method of analysis in favour of the stepwise regression procedure. In part, this was necessitated because the error variance of the parameters was not homogeneous over all parameter space (see sec. 3.5.2.1). This method of analysis will identify only the most important factors, even though the model will exhibit considerable lack of fit. It should be pointed out that using the standard approach one continues to include terms in the model until there is no apparent lack of fit. However, in this case, a statistical comparison of the expected mean parameter values (regression intercepts) with the corresponding values from the centre point runs would indicate that there is indeed a lack of fit which wouldn't be detected through variance comparison.

Whether a term would appear in the stepwise regression model for the reponse depends upon whether "F to enter" is greater than $F_{1,m,.05}$, with m being the degrees of freedom. Because of the absence of covariance between terms (due to the orthogonal design), it is unnecessary to check for term removal at any step. That is, one simply proceeds to enter terms until the "F" test fails. For the results in Tables 4.8 through 4.16, this point is marked by a solid horizontal line. The results of the stepwise regression analysis are summarized in the 9 equations below, where f(...) implies a linear functional relationship and the terms in the parentheses are arranged in order of decreasing significance. X1, X2, X3, X4, X5, X6 and X7 represent air, collector, frother, conditioning time, percent solids, impeller speed and pH, respectively, and the interactions between these factors are shown as X12, X25, etc... r^2 is the index of multiple determination, which indicates a "good" correlation with the index of one and a "poor" correlation with the index of zero for a given relationship.

Organics

$$Kf = f(-X25, -X5, X17+X56, X15+X67) \qquad r^2 = 0.50 \qquad \ldots(4.9)$$

$$Ks = f(X1, X3, -X25) \qquad r^2 = 0.42 \qquad \ldots(4.10)$$

$$\Phi = f(-X5, X35) \qquad r^2 = 0.73 \qquad \ldots(4.11)$$

Ash

$$Kf = f(-X5,\ -X25,\ X15+X67,\ X2) \qquad r^2 = 0.57 \qquad \ldots(4.12)$$

$$Ks = f(X3,\ X1, -X37,\ -X25,\ X2,\ X15+X67,\ -X7,\ -X17-X56) \qquad r^2 = 0.58 \qquad \ldots(4.13)$$

$$\phi = f(-X5,\ -X3,\ X35,\ -X1,\ -X2,\ -X13) \qquad r^2 = 0.90 \qquad \ldots(4.14)$$

Water

$$Kf = f(X6,\ X1,\ X5,\ X34) \qquad r^2 = 0.62 \qquad \ldots(4.15)$$

$$Ks = f(X5) \qquad r^2 = 0.20 \qquad \ldots(4.16)$$

$$\phi = f(-X5) \qquad r^2 = 0.51 \qquad \ldots(4.17)$$

A comment which has to made at this point concerns the rather low value of the indices of multiple determination (r^2) reported. It must be remembered that the purpose of this phase of the project was to identify important factors and not to construct process models. The existence of a good linear model between the factors and the model parameters was not required. What was required was some indication of correlation. The nature of the relationship between the parameter and a particular factor may be non-linear, however, in many cases the existence of this type of relationship will be evidenced by a significant, but weak, linear correlation. In addition, the rather "fuzzy" parameter estimates and the limited range of variation would also limit the value of r^2 (see sec. 4.4).

The terms which appear in the functional relationships of Equations 4.9 through 4.17 are those determined to be significant in the stepwise regression. By inspection, it is apparent that all of the factors, excluding X4 (conditioning time), appear alone, through interaction or both. Examining the relative position of the terms in the argument list allows the following conclusion: **At the factor levels studied in the screening test series, the most important factors governing flotation performance were identified as X1 (air), X2 (collector), X3 (frother) and X5 (percent solids).** Impeller speed, X6, appears to be significant only for $\phi(H_2O)$, as might be expected considering the possibility of flooding in the flotation experiment.

A great deal of time could be devoted to providing interpretation of the model forms, however, most are intuitive and therefore no additional comment is offered.

4.2.5.2 IDENTIFICATION OF IMPORTANT FACTORS THROUGH WEIGHTED REGRESSION ANALYSIS

In the previous section it was assumed that the variance associated with the parameter was homogeneous, for the purposes of performing the regression analysis, despite the fact that evidence indicated this to be probably erroneous. Since the data processing program provides estimates of the standard error'' of the parameters for each data set, which depend upon how well the model fits the data (RMS), it is possible to perform a weighted regression solution to the identification problem. The coefficients in the linear reponse model are obtained through minimization of the weighted least squares objective function given in Equation 4.18

$$J' = \sum \left\{ \frac{(P_i - \hat{P}_i)^2}{s^2(P_i)} \right\} \qquad \ldots(4.18)$$

where: J' =the weighted objective function.
P_i =the parameter estimate from data processing for the "i"th experiment.
$\hat{P}_i$ =the parameter estimate from the linear model incorporating the factors.
$s^2(P_i)$ =the estimate of the parameter error variance for the "i"th experiment, i.e. the square of the standard error.

With the introduction of the weighting factors, $1/s^2(P_i)$ the orthogonality disappears and the solution must be obtained using the conventional stepwise

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''The standards errors are not very good estimates but do indirectly measure the goodness of fit and therefore the certainty of the parameter estimates.

regression procedure.

For the purposes of this thesis, only the organic component was analyzed using the BMDP statistical package (37). From the program output, deriving equations similar to those above yields:

Organics

$$Kf = f(X15,\ X6,\ X47) \qquad r^2 = 0.46 \qquad \ldots(4.19)$$

$$Ks = f(X3,\ X1,\ X2,\ X12) \qquad r^2 = 0.85 \qquad \ldots(4.20)$$

$$\phi = f(-X5,\ X23,\ -X3,\ -X24) \qquad r^2 = 0.87 \qquad \ldots(4.21)$$

The model forms are somewhat different but the principal factors remain unchanged, supporting the use of the simpler unweighted procedure. It is assumed that this will hold for the other components as well and a similar analysis has been omitted.

4.2.5.3 SUMMARY

Linear regression analysis was used to identify the important factors in the screening tests. The flotation system behavior, under a given set of operating conditions, is contained in the compound first order model parameters. Regressing the parameter estimates on the terms of a complete linear model, in a forward stepwise fashion, identified the important factors. Even though the overall correlations were poor, this is thought to be the combined effect of higher order correlations and "fuzzy" parameter estimates and it does not detract from the identification. On the basis of the results the important factors at the levels studied were: air flow rate, collector dosage, frother dosage and percent solids in the flotation feed pulp.

4.2.6 OTHER MODELLING STUDIES ON THE SCREENING DATA

In some similar work on Australian coals, Lynch et al. (34) studied the effect of frother and collector dosage on the parameters of the compound first order model. Without providing statistical evidence, they state that at the factor levels studied Kf and Ks were essentially constant and ϕ was the only variable parameter in the model. They proceeded to correlate ϕ with the factors to produce a "comprehensive" model of the flotation system. To investigate the applicability of this type of model to the screening data, a multivariable search program (35) was used. Values of Kf and Ks were found which minimized the objective function in Equation 4.22.

$$J'' = \sum_{i}^{37} \sum_{j}^{5} (R_i(j) - \hat{R}_i(j))^2 \qquad \ldots(4.22)$$

where: J'' =the unweighted least squares objective function.

$R_i(j)$ =the predicted recovery for a component on the "i"the experiment and "j"th time increment.

$\hat{R}_i(j)$ =the corresponding value predicted by the constant Kf-Ks model.

Once Kf and Ks are assumed known, an estimate of ϕ for any data set is available by simple two variable linear regression. The results of this exercise show, however, at the factor levels studied in this phase, as well as the number of factors, that Kf and Ks are not constant. The residual sum of squares value averaged over all 37 runs was about a factor of 3 larger than the corresponding value for the individual model results, even considering the significant difference in the number of degrees of freedom.

4.2.7 COMMENTS

For practical/operational purposes a comment can be made on the basis of the functional forms derived in the unweighted linear regression analysis of section 4.2.5.1. Air (X_1) and frother (X_3) are present as main factor effects for ϕ(ash) and absent for ϕ(organics) indicating that they might be useful in process control, i.e. they have the ability to alter the yield-ash operating point. Moreover, these factors also appear in the Ks correlations for the solids components indicating an enhancement of the recovery rate of locked particles. Collector is present as a main factor effect in all of the ash component correlations and therefore might be useful in system optimization since it effects both equilibrium and kinetic behaviour. The percent solids term has a strong presence in almost all of the correlations. Specifically, and with respect to the solids components, increasing percent solids reduces the rate of recovery of the fast floating fraction but it also increases the amount of this material in the system. This has significant implications with respect to the design of the Gregg River Resources flotation plant which will treat a rather dilute feed stream of approximately 3% solids.

4.3 ANALYSIS OF THE INDIVIDUAL SIZE FRACTION RESULTS

4.3.1 INTRODUCTION

Since particle size was not included as a factor in the screening tests, but has been known to affect flotation performance, a separate retrospective study was conducted. The experimental portion of the work involved obtaining samples of the reject material from the size composite analyses, screening these samples and analysing the size fractions for ash. This was done for all 37 tests for each flotation increment as well as the tailings product. The sieves selected for the wet screening were 74 microns (200 mesh) and 44 microns (325 mesh) yielding information for three size fractions: +74, -74+44 and -44 microns. The data for the individual size fractions was then processed by a modified form of the size composite data processing program described in section 4.2.

4.3.2 ANALYSIS OF RESULTS

The parameters for the compound first order model were extracted from the computer program output and are presented in Tables 4.18 through 4.23. Inspection of the RMS values associated with the data sets shows a generally higher level relative to the size composite fits, particularly as size decreases. There are two contributing effects. Firstly, there is greater error in the measured data which is introduced by the sampling, screening and ash analysis steps. While not reported here, the variances on recovery for the size fractions obtained from the centre point runs are almost an order of magnitude larger than those reported for the size composite data and are observed to be largest in the two finer fractions. The second contributing effect is lack of fit and this is thought to be due to alternate flotation mechanisms (e.g. entrainment) which are not accommodated in the compound first order model.

The simple unweighted stepwise linear regression analysis yields the functional relationships between the parameters and the factors given by Equations 4.23 through 4.40. (note that a "*" implies that the some marginally significant terms have been excluded from the model.) Again, the arguments in the parentheses are arranged in order of decreasing significance.

ϕ for Organics

Table 4.18 Model Results for +200 Mesh Organic Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	78.64	1.636	0.009	0.14
2	47.51	2.445	0.051	4.94
3	53.08	2.787	0.015	1.61
4	52.93	2.675	0.086	11.57
5	30.23	2.652	0.033	3.14
6	19.73	2.012	0.109	3.64
7	33.07	2.537	0.000	39.46 *
8	18.80	3.158	0.278	3.24
9	83.16	1.421	0.007	0.05
10	74.95	0.818	0.009	0.34
11	29.92	1.850	0.019	0.56
12	48.58	3.641	0.125	7.39
13	29.90	1.516	0.014	17.29
14	29.36	1.762	0.107	5.54
15	58.13	2.865	0.154	6.42
16	34.04	2.872	0.201	3.47
17	14.13	1.079	0.000	2.42 *
18	18.55	0.922	0.000	17.60 *
19	21.66	1.161	0.013	23.57
20	9.46	2.209	0.236	3.79
21	11.45	0.524	0.000	20.52 *
22	27.13	4.650	0.727	2.23
23	12.32	1.094	0.015	1.79
24	20.90	1.904	0.273	0.60
25	11.00	0.748	0.000	12.63 *
26	11.00	2.587	0.090	3.38
27	6.16	1.155	0.001	13.51
28	6.64	1.458	0.115	0.62
29	13.06	1.649	0.175	0.83
30	9.64	1.948	0.161	8.70
31	11.23	1.159	0.010	1.25
32	1.13	1.291	0.000	6.83 *
CNTR#				
1	5.80	1.295	0.024	10.67
2	5.41	1.311	0.000	6.17 *
3	3.06	1.271	0.000	7.46 *
4	6.54	1.128	0.049	8.50
5	5.79	1.217	0.023	1.05

* Defaulted to simple first order model.

Table 4.19 Model Results For -200/+325 Mesh Organic Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	36.46	1.660	0.032	1.54
2	49.16	2.816	0.101	7.05
3	44.52	3.504	0.029	1.06
4	44.72	2.792	0.106	11.31
5	33.34	2.927	0.052	1.34
6	25.84	2.168	0.144	30.91
7	53.36	4.083	0.072	0.56
8	36.24	4.785	0.593	2.61
9	73.42	1.682	0.008	0.30
10	67.75	0.710	0.009	2.21
11	29.91	2.182	0.039	0.19
12	57.08	5.168	0.159	6.86
13	29.33	1.035	0.012	33.34
14	30.95	2.384	0.208	7.72
15	56.48	3.329	0.170	4.44
16	31.05	3.230	0.227	1.98
17	9.28	1.391	0.023	3.08
18	9.50	1.301	0.052	1.06
19	13.30	1.034	0.000	89.34 *
20	8.49	1.920	0.216	1.60
21	9.46	0.632	0.000	33.45 *
22	43.71	7.591	0.805	3.70
23	19.93	1.923	0.122	0.81
24	17.31	1.923	0.297	0.11
25	9.89	0.933	0.039	15.65
26	15.45	3.215	0.327	2.66
27	4.89	1.208	0.082	4.68
28	8.95	1.241	0.208	3.71
29	14.33	1.550	0.192	0.36
30	14.42	2.245	0.232	5.33
31	12.59	1.083	0.006	1.52
32	0.95	1.585	0.000	3.39 *
CNTR#				
1	11.84	1.400	0.067	117.55
2	10.16	1.435	0.026	33.28
3	31.51	5.658	0.232	8.16
4	1.68	0.795	0.000	25.40 *
5	24.12	1.904	0.235	4.56

* Defaulted to simple first order model.

Table 4.20 Model Results For -325 Mesh Organic Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	41.04	2.160	0.036	1.64
2	33.64	2.954	0.307	1.76
3	46.23	3.029	0.032	2.50
4	25.94	1.572	0.000	0.36 *
5	35.17	2.005	0.022	14.57
6	11.58	1.954	0.158	3.57
7	53.82	6.422	0.065	0.71
8	1.91	0.930	0.000	132.67 *
9	77.28	1.073	0.019	3.82
10	59.35	0.835	0.011	5.28
11	29.65	1.629	0.031	1.29
12	57.25	4.493	0.169	11.61
13	18.33	1.360	0.050	22.93
14	14.42	1.858	0.159	1.73
15	57.64	3.056	0.191	8.62
16	33.77	2.486	0.203	4.01
17	5.63	1.151	0.095	6.81
18	9.90	1.189	0.050	1.45
19	11.73	1.191	0.014	1.78
20	6.73	1.342	0.000	1.87 *
21	10.37	0.634	0.000	76.27 *
22	13.67	2.798	0.112	4.00
23	18.35	1.387	0.025	0.71
24	11.21	1.689	0.062	12.13
25	6.90	0.850	0.000	19.73 *
26	34.56	1.755	0.103	3.41
27	14.84	0.645	0.000	43.40 *
28	10.32	0.967	0.000	2.18
29	21.70	1.210	0.057	1.68
30	30.38	2.359	0.174	8.48
31	11.75	0.876	0.000	34.17 *
32	3.15	0.851	0.000	23.16 *
CNTR#				
1	3.63	0.900	0.000	26.33 *
2	3.85	1.216	0.000	2.03 *
3	4.29	1.342	0.000	12.51 *
4	0.51	1.177	0.000	4.86 *
5	1.72	1.109	0.000	12.35 *

* Defaulted to simple first order model.

Table 4.21 Model Results For +200 Mesh Ash Component

	Compound First Order Model				
Test#	Phi	Kf	Ks	RMS	
1	93.24	1.916	0.006	0.07	
2	77.06	2.097	0.019	1.30	
3	76.97	2.827	0.008	0.58	
4	71.80	2.288	0.042	7.04	
5	58.88	2.469	0.018	1.13	
6	35.11	1.434	0.038	3.20	
7	61.31	4.511	0.039	0.41	
8	32.61	2.065	0.048	5.56	
9	93.91	1.035	0.002	0.01	
10	89.04	0.410	0.003	0.11	
11	54.49	1.865	0.011	0.07	
12	67.99	3.111	0.044	6.17	
13	63.75	1.368	0.008	4.37	
14	56.27	1.252	0.026	2.71	
15	71.41	2.548	0.063	3.52	
16	43.09	2.455	0.098	4.71	
17	43.79	0.889	0.000	3.32	*
18	57.54	0.783	0.002	3.93	
19	42.53	1.021	0.016	10.19	
20	19.23	1.656	0.018	2.82	
21	43.21	0.389	0.000	5.08	*
22	21.46	2.703	0.075	8.92	
23	27.59	1.093	0.023	0.30	
24	26.88	1.468	0.075	1.97	
25	47.25	0.597	0.000	4.04	*
26	33.55	2.150	0.016	1.74	
27	22.11	1.063	0.005	8.86	
28	19.12	1.247	0.026	0.14	
29	28.78	1.492	0.040	0.71	
30	25.91	1.475	0.038	5.21	
31	32.73	0.984	0.009	1.74	
32	9.91	1.137	0.000	5.19	*
CNTR#					
1	19.33	1.014	0.000	2.91	*
2	26.88	1.232	0.002	3.00	
3	16.98	0.985	0.000	6.50	*
4	24.72	1.016	0.022	4.11	
5	23.95	0.983	0.010	0.19	

* Defaulted to simple first order model.

Table 4.22 Model Results For -200/+325 Mesh Ash Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	77.83	1.816	0.011	0.20
2	79.48	2.227	0.029	2.03
3	69.87	3.510	0.015	1.10
4	65.03	2.475	0.041	8.18
5	61.01	2.459	0.024	1.37
6	37.99	1.479	0.037	23.99
7	71.09	4.023	0.032	0.29
8	32.93	1.938	0.092	19.28
9	90.36	1.271	0.002	0.03
10	83.85	0.344	0.000	0.21 *
11	55.41	2.171	0.016	0.15
12	73.25	3.879	0.054	7.61
13	68.78	0.927	0.005	4.39
14	51.95	1.394	0.035	6.05
15	68.27	2.815	0.069	2.09
16	38.96	2.668	0.088	2.89
17	37.69	1.094	0.001	1.26
18	39.35	1.037	0.016	0.29
19	43.66	0.979	0.012	33.16
20	19.68	1.513	0.021	1.01
21	45.75	0.495	0.000	8.91 *
22	29.51	2.333	0.068	16.20
23	34.42	1.918	0.065	1.39
24	22.51	1.493	0.076	1.35
25	45.70	0.758	0.004	4.71
26	35.50	2.048	0.028	3.71
27	26.84	1.187	0.033	3.36
28	24.26	1.106	0.037	4.59
29	32.59	1.368	0.040	0.74
30	35.19	1.707	0.069	9.15
31	39.28	0.917	0.008	2.12
32	8.43	1.473	0.026	4.28
CNTR#				
1	39.86	1.493	0.041	49.12
2	33.65	1.272	0.011	9.41
3	54.86	2.521	0.065	14.23
4	21.64	0.703	0.000	9.51 *
5	37.09	1.230	0.049	1.84

* Defaulted to simple first order model.

Table 4.23 Model Results For -325 Mesh Ash Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	76.57	2.237	0.011	0.21
2	49.80	2.186	0.079	4.60
3	73.09	3.001	0.015	1.44
4	66.00	2.341	0.038	13.40
5	67.01	2.008	0.011	2.63
6	27.22	1.499	0.021	4.60
7	74.14	5.754	0.028	0.54
8	28.27	0.816	0.000	45.91 *
9	91.19	0.999	0.007	0.61
10	82.69	0.621	0.004	0.90
11	57.75	1.612	0.013	0.36
12	72.92	2.937	0.050	10.21
13	53.18	1.241	0.013	6.84
14	39.83	1.497	0.036	1.23
15	71.61	2.402	0.069	6.18
16	48.48	2.163	0.061	4.21
17	23.13	0.993	0.014	3.22
18	39.17	0.996	0.018	0.29
19	39.68	0.960	0.016	0.85
20	41.01	1.271	0.002	0.93
21	48.69	0.510	0.000	16.70 *
22	53.24	2.357	0.016	2.97
23	44.60	1.318	0.017	0.02
24	51.77	1.577	0.017	1.77
25	49.36	0.703	0.000	4.71 *
26	70.71	1.381	0.016	3.05
27	44.97	0.578	0.000	30.77 *
28	53.66	0.905	0.003	1.39
29	61.15	1.128	0.012	0.33
30	64.99	1.741	0.037	5.04
31	49.36	0.753	0.000	10.16 *
32	55.54	0.844	0.000	2.09 *
CNTR#				
1	25.98	0.745	0.000	8.71 *
2	24.95	1.037	0.000	1.32 *
3	29.39	1.175	0.026	9.14
4	13.24	1.039	0.000	0.79 *
5	20.07	0.979	0.026	5.27

* Defaulted to simple first order model.

+200 mesh

$\phi = f(-X5,\ X35,\ -X3,\ -X47,\ X23,\ -X45,\ -X26)^{*}$ ...(4.23)

$r^2 = 0.87$

-200+325 mesh

$\phi = f(-X5,\ X35,\ -X47)$ $r^2 = 0.73$ ...(4.24)

-325 mesh

$\phi = f(-X5)$ $r^2 = 0.37$ ...(4.25)

ϕ for Ash

+200 mesh

$\phi = f(-X5,\ -X3,\ -X2,\ -X1,\ X35,\ X23,\ -X6^{*})$ ...(4.26)

$r^2 = 0.90$

-200+325 mesh

$\phi = f(-X5,\ -X1,\ -X3,\ -X2,\ X35,\ -X13,\ -X6)$ ...(4.27)

$r^2 = 0.91$

-325 mesh

$\phi = f(X35,\ X15,\ -X5,\ X4,\ -X13)$ $r^2 = 0.66$ ...(4.28)

Kf for Organics

+200 mesh

$Kf = f(-X5,\ -X25,\ X17+X56,\ X1)$ $r^2 = 0.55$ ...(4.29)

-200+325 mesh

$$Kf = f(-X25,\ X17+X56,\ X1,\ -X5) \qquad r^2 = 0.54 \qquad \ldots(4.30)$$

-325 mesh

$$Kf = f(-X5,\ -X25) \qquad r^2 = 0.30 \qquad \ldots(4.31)$$

Kf for Ash

+200 mesh

$$Kf = f(-X5,\ -X25,\ X2,\ X15) \qquad r^2 = 0.57 \qquad \ldots(4.32)$$

-200+325 mesh

$$Kf = f(-X5,\ -X25,\ X2,\ X17+X56,\ X15) \qquad r^2 = 0.70 \qquad \ldots(4.33)$$

-325 mesh

$$Kf = f(-X5,\ -X25) \qquad r^2 = 0.33 \qquad \ldots(4.34)$$

Ks for Organics

+200 mesh

$$Ks = f(X1,\ X3) \qquad r^2 = 0.33 \qquad \ldots(4.35)$$

-200+325 mesh

$$Ks = f(X1,\ X3,\ X17+X56,\ -X25,\ -X26) \qquad r^2 = 0.59 \qquad \ldots(4.36)$$

-325 mesh
$Ks = f(-X37, X1)$ $r^2 = 0.27$ ...(4.37)

Ks for Ash

+200 mesh
$Ks = f(X3, X1, X2, -X25, X37)^{*}$ $r^2 = 0.64$ ...(4.38)

-200+325 mesh
$Ks = f(X3, X1, X2, -X37, -X25, -X7)$ $r^2 = 0.80$ ...(4.39)

-325 mesh
$Ks = f(-X5, -X37, X34)$ $r^2 = 0.44$ ...(4.40)

Inspection of the functional relationships indicates a strong similarity in form for a particular component and a particular parameter over the three size classes. (The similarity is less well pronounced in the -325 mesh fraction. This is thought to the result of a strong contribution to flotation behaviour by the water entrainment mechanism. This, in turn, is partially responsible for the poorer correlations observed for this size class.) Not only are the functional relationships similar in form, but the predicted parameter values are also similar. This is shown in Table 4.24 where the mean parameter values are tabulated for each component and for each size class. It is readily apparent that, within the limits of error, the mean parameter values are substantially independent of particle

Table 4.24 Mean Parameter Values For The Size Fractions

	Size Fraction (Mesh)					
Parameter	Organic			Ash		
	+200	-200+325	-325	+200	-200+325	-325
Phi	28.05	28.50	25.5	48.39	48.32	55.34
Kf	1.943	2.351	1.83	1.6812	1.776	1.604
Ks	0.095	0.1426	0.067	0.0255	0.329	0.0195

size. Moreover, the functional relationships derived for each size class are very similar to those obtained for the size composite data in section 4.2, as would be expected from the discussion above.

One conclusion which may be drawn from the functional relationships, and which is corroborated experimentally, is that the fine ash material is not completely liberated/detached from the organics. The evidence is the strong similarity in form for a particular parameter in a particular size class for both the organic and ash components. This liberation has often been observed to be true in other coal (and metallic) flotation systems where it can be shown that the flotation of this material is predominantly through entrainment by the water. This is evidenced by a good stable linear correlation between the corresponding fine ash and water recoveries. Such correlations were not obtained for the -325 ash material with the index of multiple correlation frequently (r^2) ≤ 0.85. Moreover, the slope/intercept values for the correlations were observed to vary substantially from test to test.

The implication of the discussion above is that the flotation of the average particle (i.e. the mass averaged behaviour over all particles in the size class) in each size class is the same, thus the particles must be very much the same, apart from size. That the particles are similar in nature is partially supported by the mass distribution of the ash with size, which is shown in Table 4.25. Clearly there is no appreciable concentration of high ash material in the finest size fraction, a trait often observed in similar coal flotation systems. This may be the result of the sample origin (see sec. 3.2). Further study of the nature of the coal particles, particularly the assembly of the solid phases was undertaken in an attempt to explain the observed floatation behaviour. Sink-and-float analysis as well as microscopic examination (optical, electron) was performed and the results are summarized below.

4.3.3 EXAMINATION OF THE SOLID PARTICULATES ASSEMBLY

The results of both sets of microscopic examinations were not very enlightening. From the optical microscopic examination the only observation of interest was that the heaviest specific gravity fraction consisted primarily of free inorganic material. The scanning electron microscope (SEM) investigation provided little additional information. Using X-ray fluorescence analysis in conjunction with electron microscopy allowed a qualitative elemental analysis of the coal particles. It was hoped that this would provide some information on the nature of the ash association with the organic phase. Studies on all three size classes showed only the existence of relatively fine inorganic particles (less than or equal to 3 microns) on or in the coal particle surface. The origin of these inorganic particles, i.e from air-borne dust or as colloidally dispersed inherent ash was

Table 4.25 Ash Distribution For Size Fractions

Size Fraction (Mesh)	Estimated Mean Ash Content
+200	10.82%
-200+325	11.93%
-325	12.34%

not determined. Present evidence seems to indicate the latter.

Perhaps the most enlightening of this series of tests was the sink-and-float fractionation. A representative sample of the feed was screened to produce samples of the three size classes of interest. All four of the coal samples were then subjected to sink-and-float analysis using the following liquids: 1.3, 1.33, 1.45, 1.8 and 2.2 specific gravity. The float fractions were dried, weighed and subsequently analysed for ash content. Using the results of the screen analysis, the mass distribution from the sink-and-float tests as well as the ash assays, the raw data was adjusted using minimum variance techniques (35). (It is worth noting that the adjustemts were all very small, i.e. within one estimated standard deviation, suggesting good experimental precision.) The resulting washability data is presented in Table 4.26 and the two curves of interest are plotted on Figure 4.1, for all four samples.

One comment which requires to be made at this point relates to the data for the -325 mesh and feed samples. Performing sink-and-float analyses on very fine coal is extremely difficult. While great care was taken in this work to ensure the best possible results it still cannot be stated with certainty that the washabilty data for this size fraction differs significantly from that for the coarser sizes, even though the results suggest that this is true. Morover, since the feed is composed of approximately 48%

Table 4.26 Washability Data For The Gregg River Fine Coal

Frequency Data

			Size Fraction (Mesh)					
	Feed		+200		-200+325		-325	
S.G.	% Wt.	% Ash	% Wt.	% Ash	% Wt.	% Ash	% Wt	%Ash
1.30	16.55	2.32	29.46	2.16	28.49	2.18	2.70	4.13
1.33	16.18	3.39	18.57	2.80	23.67	3.57	11.72	3.93
1.45	51.57	9.60	34.24	9.47	31.32	8.94	68.64	9.76
1.80	10.27	26.03	12.80	23.99	10.78	22.34	11.28	30.14
2.20	1.86	60.45	2.43	60.64	1.87	66.07	1.42	57.41
2.70	3.57	80.52	2.50	82.51	3.87	85.70	4.24	83.18

Cumulative Data

			Size Fraction (Mesh)					
	Feed		+200		-200+325		-325	
S.G.	% Wt.	% Ash	% Wt.	% Ash	% Wt.	% Ash	% Wt	%Ash
1.30	16.55	2.32	29.46	2.16	28.49	2.18	2.70	4.13
1.33	32.73	2.85	48.03	2.41	52.16	2.81	14.42	3.97
1.45	84.30	6.97	82.27	5.35	83.48	5.11	83.06	8.75
1.80	94.57	9.04	95.07	7.86	94.26	7.08	94.34	11.31
2.20	96.43	10.04	97.50	9.17	96.13	8.23	95.76	11.99
2.70	100.00	12.66	100.00	11.01	100.00	11.23	100.00	15.01

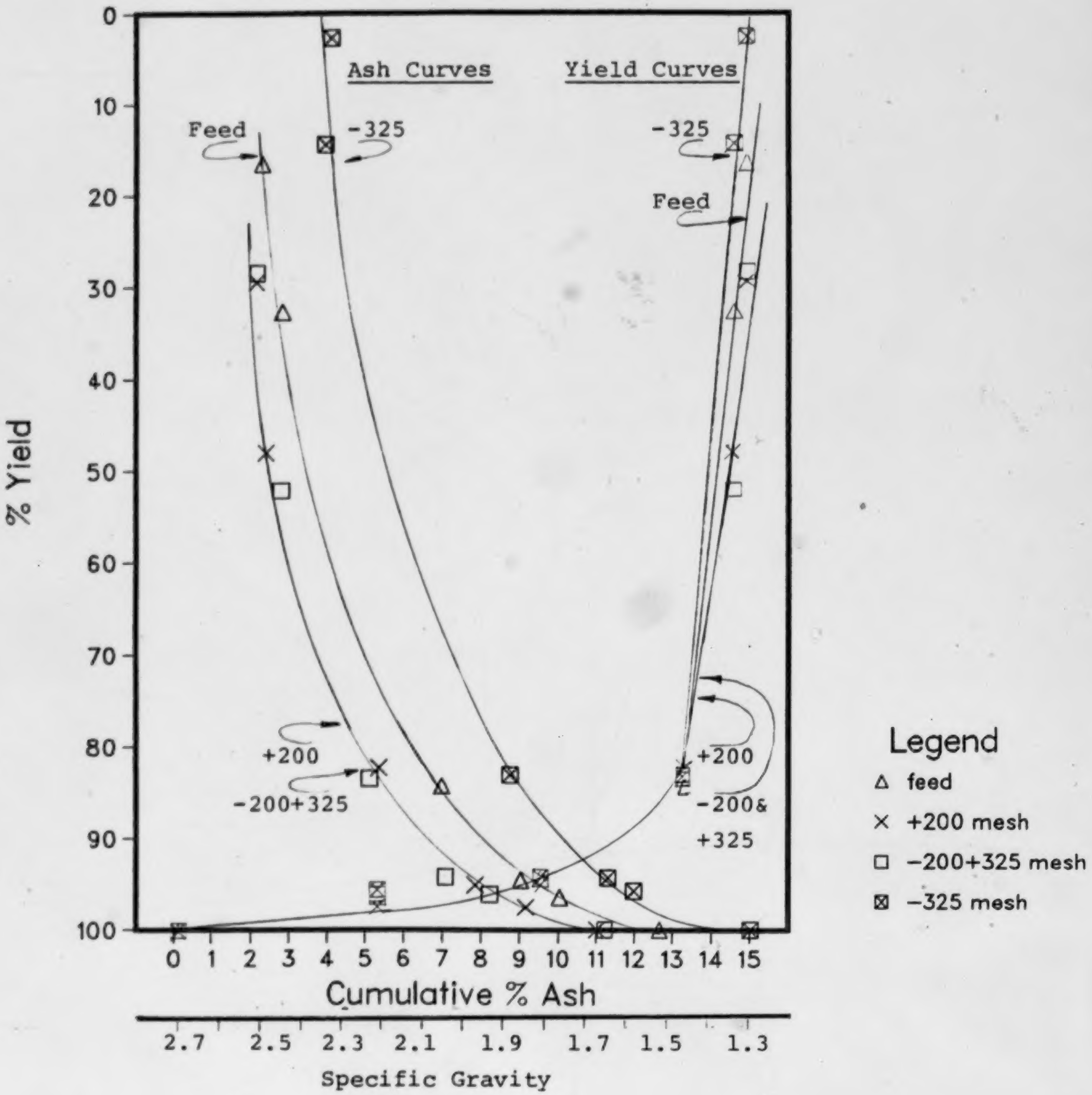

Figure 4.1 Washability Curves For The Gregg River Fine Coal

-325 mesh material by weight, the same experimental difficulties can arise in processing this sample. Nevertheless, the following statements can be made regarding the washability data:

1) Apart from size, the +200 mesh and -200+325 mesh size classes are physically identical.
2) The ash content of the -325 mesh fraction was (approximately 15%) higher in this analysis than for the flotation tests (approximately 13%); this may be partially responsilble for a translation of the -325 mesh and feed curves "away" from the coarser size classes.
3) In all cases, very little of the material (less than 3%) was contained in the +2.2 specific gravity fraction, suggesting minimal dilution.

In considering this evidence, it can be assumed that there is relatively little difference in the physical properties of the coal particles for all three size classes. Moreover, the observation of extensive locking would tend to make the separation a difficult one because of the high inherent floatability of coaly particles. Clearly, the basic model assumptions of free ash and free organics are not consistent with observation and this is confirmed by the very strong similarity in the model parameter functional relationships for the ash and organic phases.

4.3.4 SUMMARY

On the basis of the evidence from the microscopic and specific gravity fractionation analyses, it can be stated that, apart from size, there is little difference in the physical properties of the particles. It can be concluded on the basis of this analysis that, at the factor levels tested, the individual size fractions behave in an identical manner and thus the size composite approach to interpreting experimental results is a reasonably complete description of flotation system behaviour.

4.3.5 COMMENTS

For practical/operational purposes a couple of comments can be made on the basis of the functional forms of the parameter correlations obtained in the stepwise regression. As noted, the parameter correlations for the different size fractions were all very similar in form to the size composite correlations developed in section 4.2. There is, however, generally poorer correlation (low r^2) for the -325 mesh fraction than for the others. This is probably the result of the expected higher contribution of water entrainment as a recovery mechanism for the very fine material. The compound first order model does not include this phenomenon. Also, in the case of the organics the conditioning time-pH interaction effect is significant and an increase in both will serve to reduce ϕ. This may be due to the presence of minor amounts of acidic surface oxidation products which can be "neutralized" in the basic pulp given sufficient time. The oxidation is almost certainly the result of prolonged sample storage prior to use. This effect was also observed in the weighted regression analysis of section 4.2.5.2 (see Equation 4.18). Another subtle effect is that of air on the flotation rate (Kf) of the organics, for the coarser size classes. To improve the recovery of coarse clean particles it may be necessary to appropriately adjust the aeration rate. The comments of section 4.2.7 are generally applicable in this portion of the study as well.

4.4 ANALYSIS OF THE MODELLING TEST RESULTS

4.4.1 INTRODUCTION

A series of modelling tests were performed in an attempt to develop a "comprehensive" model of the Gregg River Resources coal flotation system. This section deals with the results of the experimental design and data analysis in this phase of the project.

4.4.2 EXPERIMENTAL DESIGN FOR MODELLING TESTS

From the results of the factor screening series of tests, a number of options for the general design of the modelling series were generated:

a) A 2^5 (air, collector, conditioning time, frother, %solids) design which more closely bounds the expected operating levels at Gregg River Resources.

b) A 2^4 (air, collector, frother, % solids) design with "star-points" to provide for estimates of second order effects.

c) A 2^3 (air, collector, frother) design with "star-points".

(Options (a) through (c) represent increasing practicality at the expense of broader process understanding.) It was decided to pursue option (b), after discussion with the Gregg River Resources personnel. Subsequently, a central composite 2^4 design with centre point repeat runs was developed. Table 4.27 shows the factor levels selected for study and the experimental design in coded form.

In order to look at low (near starvation)[12] levels for these factors, a preliminary set of experiments was done to investigate the possibility of reducing the reagent levels reported in Table 4.27. A 2^2 design was used for the preliminary experiments with air and % solids held at the centre point levels. For each experiment the equilibrium yield and product ash were obtained. The design and results of the preliminary experiments are given in Table 4.28. Notice that the high levels of reagent for the preliminary tests correspond to the low levels in Table 4.27. On the basis of the product yield alone it was determined that lower reagent levels would provide information outside of the region of practical interest and the design in Table 4.27 was adopted.

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[12] Low reagent levels were of particular interest to the Gregg River Resources personnel.

Table 4.27 The Complete Experimental Design For The Modelling Tests

OPERATING VARIABLES			Center points(0)		Min(-1)	Max(+1)
X1	=	air	3.5	l/min	2.0	5.0
X2	=	collector(fuel oil)	0.444	l/tonne	0.296	0.592
X3	=	frother(MIBC)	0.1866	l/tonne	0.1244	0.2488
X4	=	% solids in feed pulp	4.5	%	3.0	6.0
X5	=	conditioning time	1.0	min		
X6	=	impeller speed (power)	950	rpm		
X7	=	pH	7.8			

RUN	X1	X2	X3	X4
1	-1	-1	-1	-1
2	1	-1	-1	-1
3	-1	1	-1	-1
4	1	1	-1	-1
5	-1	-1	1	-1
6	1	-1	1	-1
7	-1	1	1	-1
8	1	1	1	-1
9	-1	-1	-1	1
10	1	-1	-1	1
11	-1	1	-1	1
12	1	1	-1	1
13	-1	-1	1	1
14	1	-1	1	1
15	-1	1	1	1
16	1	1	1	1
CNTR1	0	0	0	0
CNTR2	0	0	0	0
CNTR3	0	0	0	0
CNTR4	0	0	0	0
CNTR5	0	0	0	0
CNTR6	0	0	0	0
STR1	-1	0	0	0
STR2	1	0	0	0
STR3	0	-1	0	0
STR4	0	1	0	0
STR5	0	0	-1	0
STR6	0	0	1	0
STR7	0	0	0	-1
STR8	0	0	0	1

Table 4.28 The Results Of The Preliminary Tests On Reagent Dosage

OPERATING VARIABLES	Center points(0)		Min(-1)	Max(+1)
X1 = air	3.0	l/min		
X2 = collector(fuel oil)	0.2072	l/tonne	0.1184	0.296
X3 = frother(MIBC)	0.933	l/tonne	0.0622	0.1244
X4 = % silids in feed pulp	4.5	%		
X5 = conditioning time	1.0	min		
X6 = impeller speed (power)	950	rpm		
X7 = pH	7.8			

RUN	X3	X4	% ASH	% YIELD
1	-1	-1	6.68	36.98
2	1	-1	6.07	41.38
3	-1	1	5.78	49.95
4	1	1	5.96	58.56

4.4.3 ANALYSIS OF THE MODELLING TEST RESULTS

From the output of the data processing program, the compound first order model parameter estimates are reported in Tables 4.29, 4.30 and 4.31. For this series of tests the parameter models were developed using the parameter estimates from all 30 tests and a conventional stepwise linear regression program[13]. The general form of the functional relationships are given in Equations 4.41 through 4.49.

ORGANICS

$$\phi = f(-X4, -X3, -X1, X11, X34, -X44) \qquad r^2 = 0.91 \qquad \ldots(4.41)$$

$$Kf = f(-X4, X44) \qquad r^2 = 0.59 \qquad \ldots(4.42)$$

$$Ks = f(-X14, -X134, -X44, X11) \qquad r^2 = 0.52 \qquad \ldots(4.43)$$

ASH

$$\phi = f(-X4, -X3, -X1, X11) \qquad r^2 = 0.85 \qquad \ldots(4.44)$$

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[13] This was carried out by using the BMDP statistical package (37). One example of this output is contained in Appendix V.

Table 4.29 Compound First Order Model Parameter Estimates For The Organic Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	80.04	1.603	0.025	0.02
2	63.19	1.740	0.033	0.95
3	81.26	1.794	0.031	0.18
4	57.12	2.146	0.040	4.00
5	45.25	1.357	0.042	1.53
6	33.28	1.806	0.070	0.37
7	47.96	1.612	0.055	2.16
8	34.05	1.567	0.093	8.69
9	45.76	1.271	0.045	3.10
10	29.93	1.345	0.047	1.25
11	40.18	1.218	0.052	6.02
12	20.80	1.058	0.024	0.91
13	31.01	0.993	0.070	3.53
14	7.68	0.850	0.000	11.31 *
15	39.20	1.271	0.104	5.41
16	6.75	0.959	0.000	11.56 *
CNTR#				
1	37.02	1.489	0.060	5.59
2	33.40	1.284	0.043	8.43
3	37.88	1.469	0.081	5.68
4	42.28	2.020	0.075	1.18
5	34.24	1.588	0.049	0.70
6	31.45	1.440	0.058	8.18
STR PT				
1	43.52	1.567	0.058	4.07
2	51.76	2.270	0.119	8.62
3	29.43	1.565	0.033	4.48
4	37.32	1.530	0.067	1.13
5	45.44	1.627	0.050	1.83
6	13.76	1.590	0.045	1.68
7	44.36	1.890	0.057	4.58
8	9.48	0.989	0.000	7.13 *

* Defaulted to simple first order model.

Table 4.30 Compound First Order Model Parameter Estimates For The Ash Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	92.42	1.653	0.008	0.01
2	85.79	1.738	0.011	0.13
3	91.91	1.652	0.010	0.03
4	81.60	1.638	0.013	1.22
5	75.90	1.318	0.013	0.31
6	65.68	1.607	0.021	0.10
7	76.45	1.565	0.016	0.45
8	63.20	1.375	0.023	2.63
9	75.21	1.219	0.011	0.57
10	62.06	1.187	0.013	0.24
11	70.64	1.189	0.016	1.41
12	56.69	0.993	0.011	0.47
13	65.08	0.877	0.015	0.60
14	43.17	0.704	0.000	4.88 *
15	67.43	1.180	0.027	1.15
16	43.60	0.801	0.000	2.66 *
CNTR#				
1	69.63	1.411	0.015	1.21
2	67.16	1.217	0.010	1.80
3	68.71	1.344	0.019	1.32
4	71.21	1.836	0.017	0.53
5	67.76	1.493	0.012	0.18
6	64.63	1.334	0.014	2.07
STR PT				
1	73.21	1.448	0.014	0.75
2	72.95	1.813	0.030	4.19
3	64.92	1.408	0.013	1.38
4	67.86	1.397	0.015	0.32
5	74.27	1.505	0.012	0.50
6	45.73	1.313	0.015	0.66
7	74.84	1.780	0.016	1.01
8	43.81	0.874	0.000	2.76 *

* Defaulted to simple first order model.

Table 4.31 Compound First Order Model Parameter Estimates For The Water Component

	Compound First Order Model			
Test#	Phi	Kf	Ks	RMS
1	96.92	0.901	0.008	0.00
2	97.37	1.865	0.008	0.01
3	98.10	1.128	0.010	0.00
4	97.00	0.920	0.007	0.01
5	96.17	1.457	0.009	0.00
6	95.40	1.877	0.011	0.02
7	96.19	1.765	0.009	0.00
8	95.64	1.841	0.010	0.01
9	91.88	1.378	0.008	0.06
10	85.50	0.931	0.008	0.02
11	94.23	1.612	0.010	0.07
12	91.91	1.357	0.013	0.03
13	91.42	1.343	0.007	0.04
14	83.21	0.535	0.000	0.76 *
15	91.46	1.573	0.010	0.09
16	88.72	1.033	0.008	0.17
CNTR#				
1	93.05	1.278	0.008	0.05
2	93.21	1.231	0.007	0.02
3	92.84	1.395	0.009	0.04
4	93.43	1.756	0.009	0.06
5	92.78	1.462	0.006	0.02
6	92.78	1.319	0.007	0.07
STR PT				
1	95.02	1.766	0.010	0.01
2	93.16	1.609	0.009	0.25
3	92.70	1.376	0.012	0.03
4	92.60	1.193	0.008	0.02
5	93.25	1.253	0.008	0.03
6	88.76	0.880	0.011	0.06
7	95.82	1.413	0.009	0.02
8	89.49	1.092	0.008	0.09

* Defaulted to simple first order model.

$$Kf = f(-X4, -X3, -X44) \qquad r^2 = 0.75 \qquad \ldots(4.45)$$

$$Ks = f(-X14, -X134) \qquad r^2 = 0.32 \qquad \ldots(4.46)$$

WATER

$$\Phi = f(-X4, -X1, -X3, -X14, X2, X24, X124, X12, X11, -X33) \qquad r^2 = 0.97 \qquad \ldots(4.47)$$

$$Kf = f(X14, X34, X4, X124) \qquad r^2 = 0.54 \qquad \ldots(4.48)$$

$$Ks = f(-X34, X24, -X134) \qquad r^2 = 0.44 \qquad \ldots(4.49)$$

The very strong similarity in model form for the solids components provides further evidence of the close association of ash and organics discussed in section 4.3. This similarity precludes any speculative discussions on how to selectively float the organic component, although frother appears to be a likely candidate for manipulation. Moreover, it appears that at the levels studied in this series of tests, collector was not significant. This will be discussed in more detail in the next section.

Before proceeding to discuss the results of the comprehensive modelling study, it is first necessary to demonstrate that the compound first order model is capable of accurately characterizing the observed data from which it was derived. Table 4.32 illustrates the predictions of the model against the observed froth concentrate attributes. The comparison was made for the best, average and worst fits in the modelling series as measured by the cumulative RMS over all slurry components. For the purposes of this work it was necessary to consider only the worst case, for if it was acceptable then all other fits would be acceptable as well. (Inspection of the RMS columns in Tables 4.29 through 4.31 indicate no lack of fit.) In the opinion of the author, the predictions of the froth concentrate attributes were perfectly acceptable for the worst case fit.

Turning to the comprehensive model development, it is clear that the functional relationships for Kf and Ks are not particularly good (low values of r^2). It is convenient to now ask the questions: (1) What is the expected value of r^2 for a parameter model exhibiting no lack of fit?, and (2) Do the parameter models of Equations 4.41 through 4.49 exhibit lack of fit? The following calculations attempt to answer these questions. It is assumed that the error variance is homogeneous over the range of the parameter.

Firstly, with regard to r^2, from linear regression theory the following identity can be written:

Table 4.32 Best, Typical And Worst Fits For The Compound First Order Model

Case 1: Best Fit *(Test # 1)*

Cumulative Recovered Solids (%)		Cumulative Ash		Cumulative % Solids	
pred.	obsr.	pred.	obrs.	pred.	obrs.
11.13	11.01	4.94	5.03	20.01	19.27
16.61	16.75	4.94	5.05	17.75	17.90
21.40	21.28	4.93	5.01	15.01	15.11
25.59	25.58	4.96	5.02	12.63	12.55
32.08	32.05	5.05	5.14	10.85	10.85

Case 2: Typical Fit (STR # 1)

pred.	obsr.	pred.	obrs.	pred.	obrs.
29.81	28.47	5.80	5.74	29.89	29.31
44.06	46.08	5.88	5.76	29.66	30.18
55.02	53.96	6.00	5.88	28.50	28.44
61.24	61.58	6.06	5.99	25.60	25.59
68.10	68.15	6.14	6.03	21.40	21.44

Case 3: Worst Fit (Test # 14)

pred.	obsr.	pred.	obrs.	pred.	obrs.
30.18	27.20	6.59	6.50	28.52	24.15
50.03	48.87	6.79	6.52	27.25	26.04
71.61	76.02	7.08	7.05	25.27	26.07
85.01	84.23	7.43	7.30	23.00	24.35
88.01	87.04	7.60	7.54	21.68	20.79

$$SS(Mean) = SS(Reg.) + SS(Res.) \qquad \ldots(4.50)$$

where: SS(Mean) =sum of squares about the mean.
SS(Reg.) =sum of squares due to regression.
SS(Res.) =sum of squares about the regression (or due to residual).

By definition:

$$r^2 = 1 - \frac{SS(Res.)}{SS(Mean)} \qquad \ldots(4.51)$$

Since SS(Mean) is available from the data for the 30 tests, if an estimate of SS(Res.) can be obtained then an estimate of r^2 can be made. Assuming no lack of fit, then the error variance on the parameter can be computed from SS(Res.) as:

$$S^2 = SS(Res.)/m \qquad \ldots(4.52)$$

where: s^2 =the error variance of the dependent variable (i.e. the parameter).
m =degrees of freedom associated with SS(Res.).

Under the assumption of homogeneity, the parameter estimates from the centre point runs can be used to compute an estimate of s^2 and, by rearrangement of Equation 4.52, with m=29, SS(Res.) is available. With SS(Mean) and SS(Res.), the expected maximum value of r^2 is calculated. Of course it is possible to obtain values in excess of these estimates either because of the nature of the data itself or as a manifestation of inhomogeneity in the parameter error variance. The results of the calculations are tabulated in Table 4.33 and the values help to rationalize the rather low r^2 values reported for Kf and Ks.

Carrying the above analysis one step further, lack of fit can be tested by comparing the estimates of parameter error variance obtained through the regression residuals to the indendent estimate obtained from the centre point runs. The results of the appropriate "F-test" are shown in Table 4.34 and from these it can be concluded that, at least for the most part, the correlations do not exhibit lack of fit.

While from a purely statistical point of view the parameter models are acceptable, the strength of the correlations are such that one is immediately skeptical about the predictive ability of a comprehensive model incorporating these correlations. The skepticism is justified for, in general, the back calculated data for the modelling runs using the explicit forms of the parameter correlations compares poorly with the observed data. The computer program in FORTRAN, data table and results of this exercise are presented in Appendix VI.

On this basis it can be concluded that a comprehensive model of the form described above cannot be developed for the Gregg River Resources coal flotation system. As a result the optimization exercise (see chap. 1) which was to complete the project cannot be performed. It must be observed , however, that this was *not* because the individual data sets could not be modelled, rather the problem lies in

Table 4.33 Expected Values Of r^2 With No Lack Of Fit

Parameter	Expected Maximum Values Of r^2		
	Organics	Ash	Water
Phi	0.95	0.97	0.99
Kf	0.47	0.49	0.67
Ks	0.72	0.76	0.71

Table 4.34 Results Of F-Test For Lack Of Fit

Parameter	Organics	Ash	Water
Phi	No LOF	Marginal LOF	Marginal LOF
Kf	No LOF	No LOF	No LOF
Ks	No LOF	Marginal LOF	No LOF

LOF = Lack Of Fit

the development of the correlations. In particular, it lies predominantly with the error in the raw data. It is further concluded that even with the best available flotation machine, as measured by experimental reproducibility, given the narrow range of variation of Kf and Ks, similar attempts at model development would fail.

On the basis of the findings in this chapter a comprehensive model of the Gregg River coal floation system cannot be developed. Therefore, a model cannot be used to conduct off-line studies of system performance. However, a great deal of useful data has been generated, and in order to "milk" process information from it, another, more qualitative, method of treatment was employed. The results of this work are described in the next section.

4.5 A QUALITATIVE ANALYSIS OF THE EXPERIMENTAL RESULTS

4.5.1 INTRODUCTION

It was observed in the previous section that the objective of developing a mathematical model of the Gregg River Resources coal flotation system could not be realized, primarily because good model parameter correlations were not available. This is indeed unfortunate since such a process model would have been extremely useful both in system investigation as well as in optimization. Never the less, in conducting the 67 (37 screening + 30 modelling) batch flotation tests a great deal of process information was generated. In the absence of a model for process interpretation this chapter presents a more qualitative approach in summarizing the experimental results.

Since this thesis is intended to provide information which will assist the operators in the optimization and control of the Gregg River Resources froth flotation circuit, the analysis which follows is based upon expected plant results under operating conditions identical to those studied. To scale the laboratory batch results to the continuous system it was assumed that:

a) the flotation model parameters obtained in the laboratory work were reasonable estimates of those expected in the plant.

b) the residence time distribution of the 4 cell bank configuration employed at Gregg River Resources can be characterized as 4 equal volume perfect mixers in series.

The appropriate form of the compound first order model is given by Equation 4.53.

$$R = (100-\phi)\left\{1-\left(\frac{1}{1+ Kf\,\tau/4}\right)^4\right\} + \phi\left\{1-\left(\frac{1}{1+ Ks\,\tau/4}\right)^4\right\} \quad \ldots(4.53)$$

where: τ =mean residence time of the entire flotation cell bank.

Based upon material balance information on the design flowsheet provided by Gregg River Resources, the mean residence time was estimated to be $\tau \simeq 2.6$ minutes. Using this value and the parameter estimates from the batch tests the expected values for yield, ash and % solids in the plant froth concentrate were calculated. The results of these calculations are presented in Tables 4.35 and 4.36, for the screening series and modelling series respectively.

For the purposes of the discussion which follows it is assumed that these results are truly representative of plant operation.

4.5.2 ANALYSIS OF RESULTS

One of the most valuable relationships in process opimization and process control is the yield versus ash curve. Using the combined data of Tables 4.35 and 4.36, the expected relationship was plotted and is shown on Figure 4.2. The data from each series of laboratory tests is distinguished by the plotting symbol and the yield-ash "envelope" is sketched for both data sets. The darker region represents the modelling series of tests. From the operator's point of view, the best operating yield-ash curve is one which maximizes yield at a given ash value. With respect to Figure 4.2 this would correspond to the upper edge of the envelope. In any case it would be useful to know which variables have a major impact both on curve displacement and on inducing travel along the curve.

It is quite clear from Figure 4.2 that there is considerably more variation in the yield-ash data for the

Table 4.35 Predicted Plant Froth Product Attributes For The Screening Series

	Fractional Factorial Design		
Test#	% yield	% ASh	% Solids
1	41.69	4.97	18.51
2	61.00	6.36	17.47
3	44.81	6.78	16.34
4	52.52	7.20	20.08
5	66.12	7.38	21.55
6	76.61	8.71	18.13
7	58.27	7.98	13.73
8	83.86	8.73	19.14
9	28.01	5.35	11.78
10	31.69	5.04	13.27
11	62.57	7.53	18.52
12	56.20	7.03	15.54
13	64.27	6.13	18.52
14	73.00	7.16	19.14
15	56.68	7.61	20.10
16	72.74	8.92	21.64
17	76.70	7.98	29.83
18	77.17	7.72	30.47
19	71.76	8.30	30.91
20	88.71	9.73	27.80
21	64.54	7.39	28.60
22	89.95	9.44	26.95
23	77.83	9.74	29.38
24	85.47	10.96	28.55
25	73.80	7.32	29.29
26	85.40	8.44	29.18
27	81.74	9.77	30.18
28	82.94	9.28	28.75
29	80.57	8.93	27.99
30	85.40	9.21	28.91
31	76.56	8.38	29.05
32	89.67	10.24	29.60
CNTR#			
1	81.03	8.90	27.88
2	80.82	8.86	33.82
3	79.80	8.53	28.45
4	79.01	8.80	29.09
5	81.16	8.76	29.64

Table 4.36 Predicted Plant Froth Product Attributes For The Modelling Series

	Factorial Design		
Test#	% yield	% ASh	% Solids
1	22.04	4.94	12.95
2	37.26	5.13	20.32
3	22.43	5.35	14.18
4	43.90	5.49	24.06
5	51.36	5.74	21.55
6	65.16	6.60	22.13
7	51.75	5.85	21.49
8	65.32	6.90	23.38
9	50.77	5.79	25.68
10	63.99	6.78	22.50
11	55.45	6.33	31.07
12	66.88	7.00	28.93
13	60.68	6.26	28.90
14	72.57	7.32	28.36
15	60.69	6.68	27.20
16	75.75	7.26	29.32
CNTR#			
1	60.04	6.15	25.56
2	60.27	6.25	26.64
3	60.95	6.31	24.69
4	59.14	6.21	24.88
5	61.89	6.24	26.34
6	64.01	6.52	26.69
STR PT			
1	55.28	5.97	26.63
2	56.81	6.61	23.74
3	64.61	6.43	24.14
4	60.70	6.39	25.05
5	53.29	5.93	23.80
6	78.94	7.82	23.83
7	55.51	5.84	22.02
8	74.35	7.57	29.92

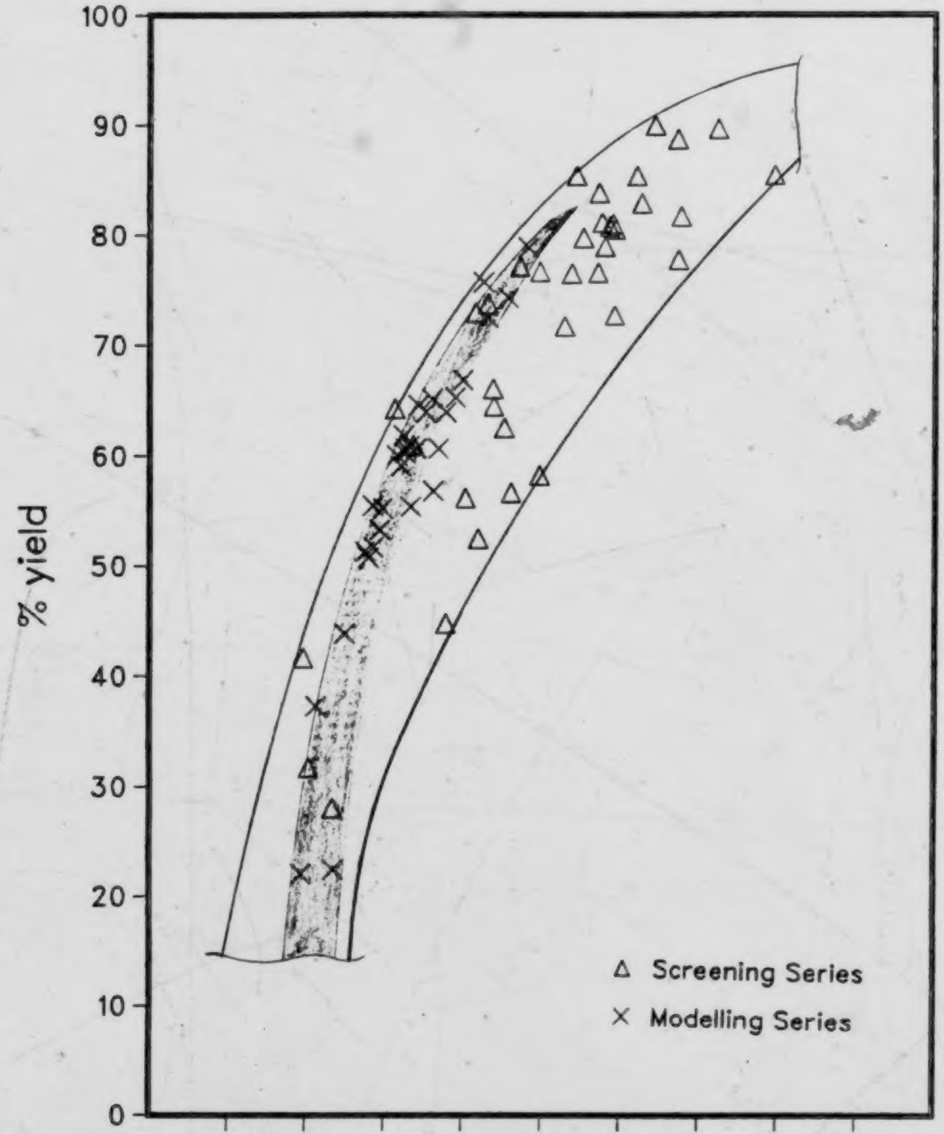

Figure 4.2 The Estimated Yield-Ash Curve For The Plant

screening series than for the modelling series. This was to be expected since the factors were tested at more extreme levels and there were more factors for the former. It must also be remembered that at least part of the variation arises from the error which is inherent in the batch flotation experiment itself. For this reason it is impossible to speculate on causal relationships when considering only a few of the data points (say less than or equal to 5). However, trends which persist over a large number of the data points carry meaningful information regarding the yield-ash curve. To examine the data for trends the screening series was chosen since it was expected that with the larger range of factor levels, the "noise" contribution to the data would be minimized. For each factor ($X_1 \rightarrow X_7$) a yield-ash plot of the data from Table 4.35 was prepared where the low and high factor levels were distinguished by the plotting symbol. The results of this exercise are presented in Figures 4.3 through 4.9.

In examining the plots one can look for two types of trends:

a) **Stratification:** if the data points are stratified with respect to the ordinate, over the entire range of the yield-ash relationship, then the factor under consideration apparently has the ability to cause displacement of the curve. As a result it can be considered an optimization variable since its manipulation can alter the yield at a given ash

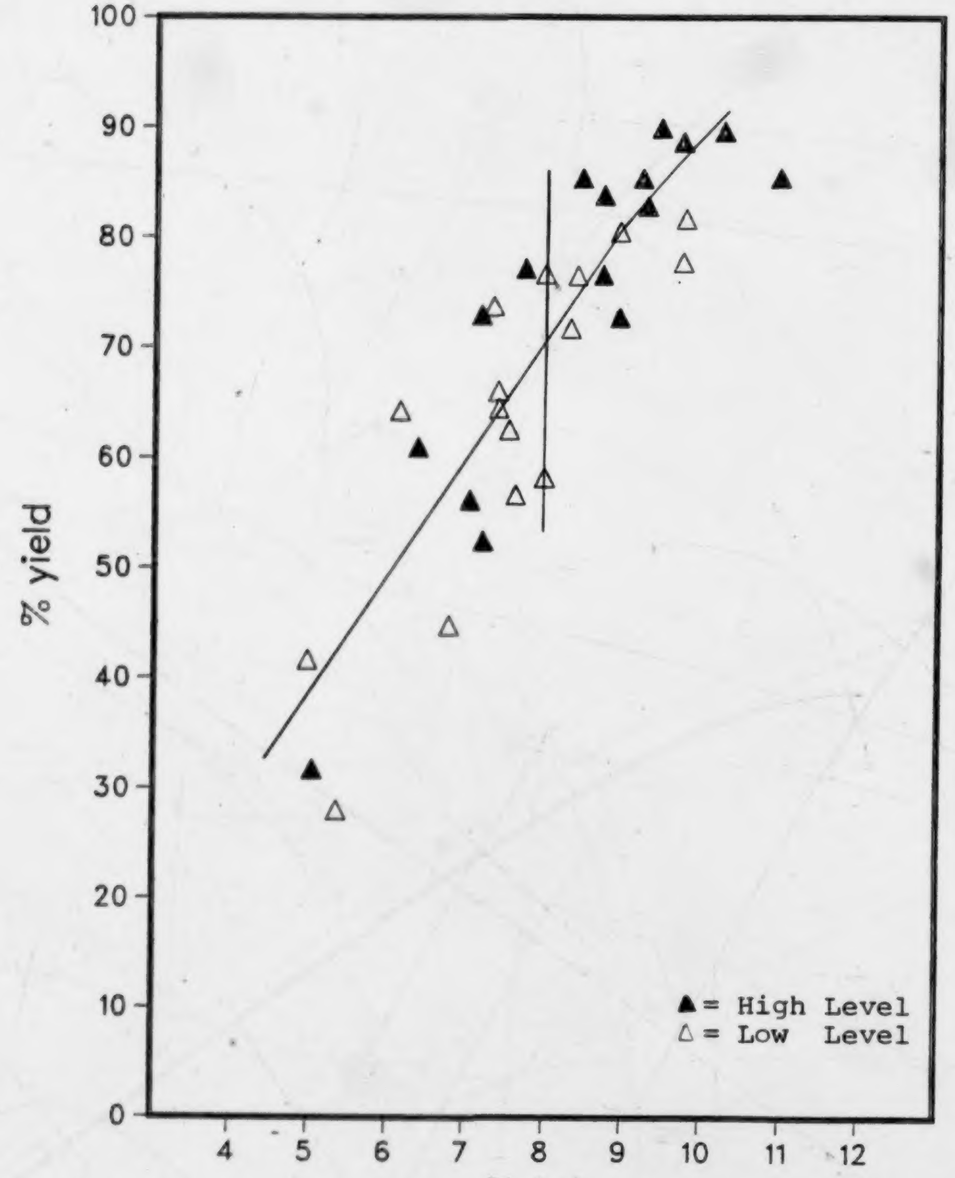

Figure 4.3 Yield-Ash Trends For Air In The Screening Series

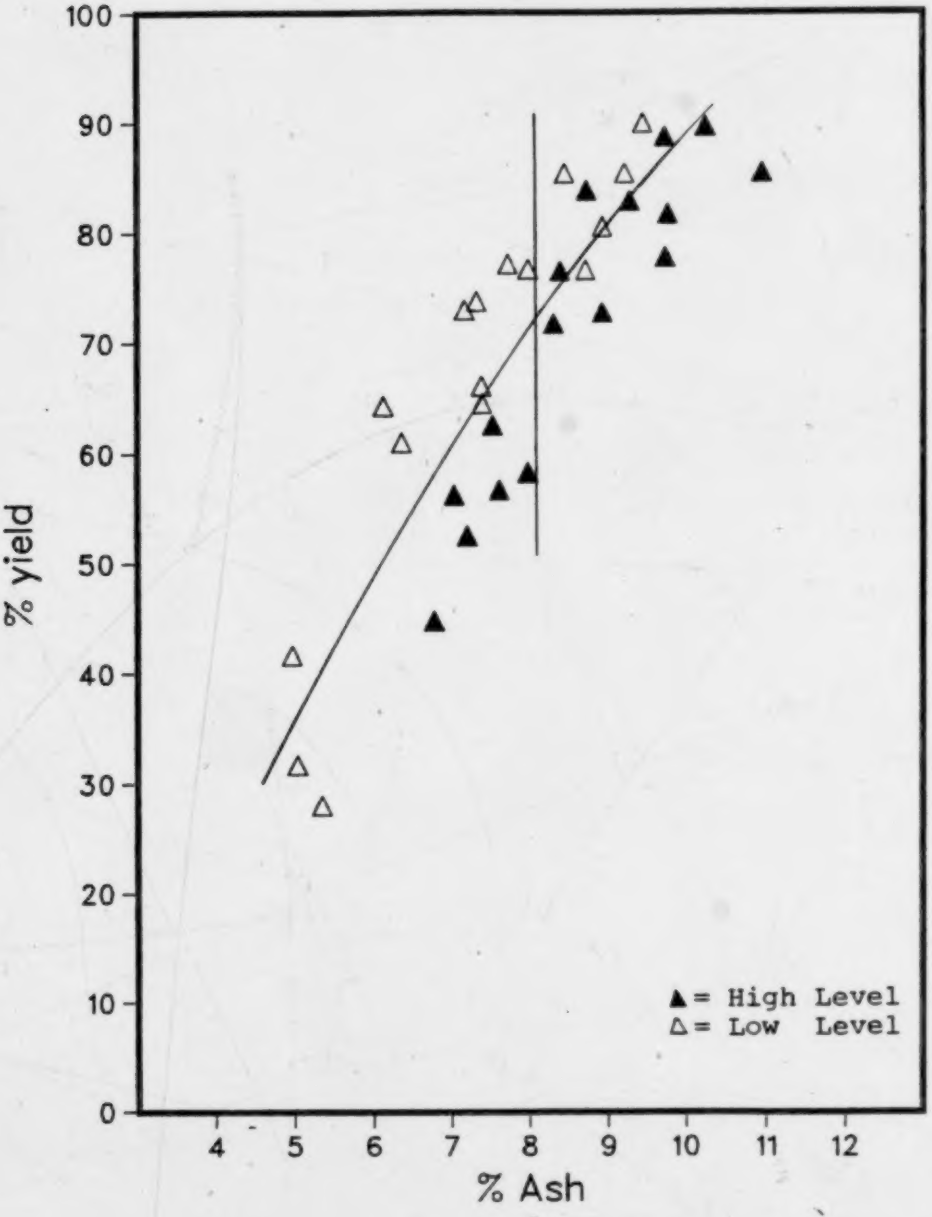

Figure 4.4 Yield-Ash Trends For Collector In The Screening Series

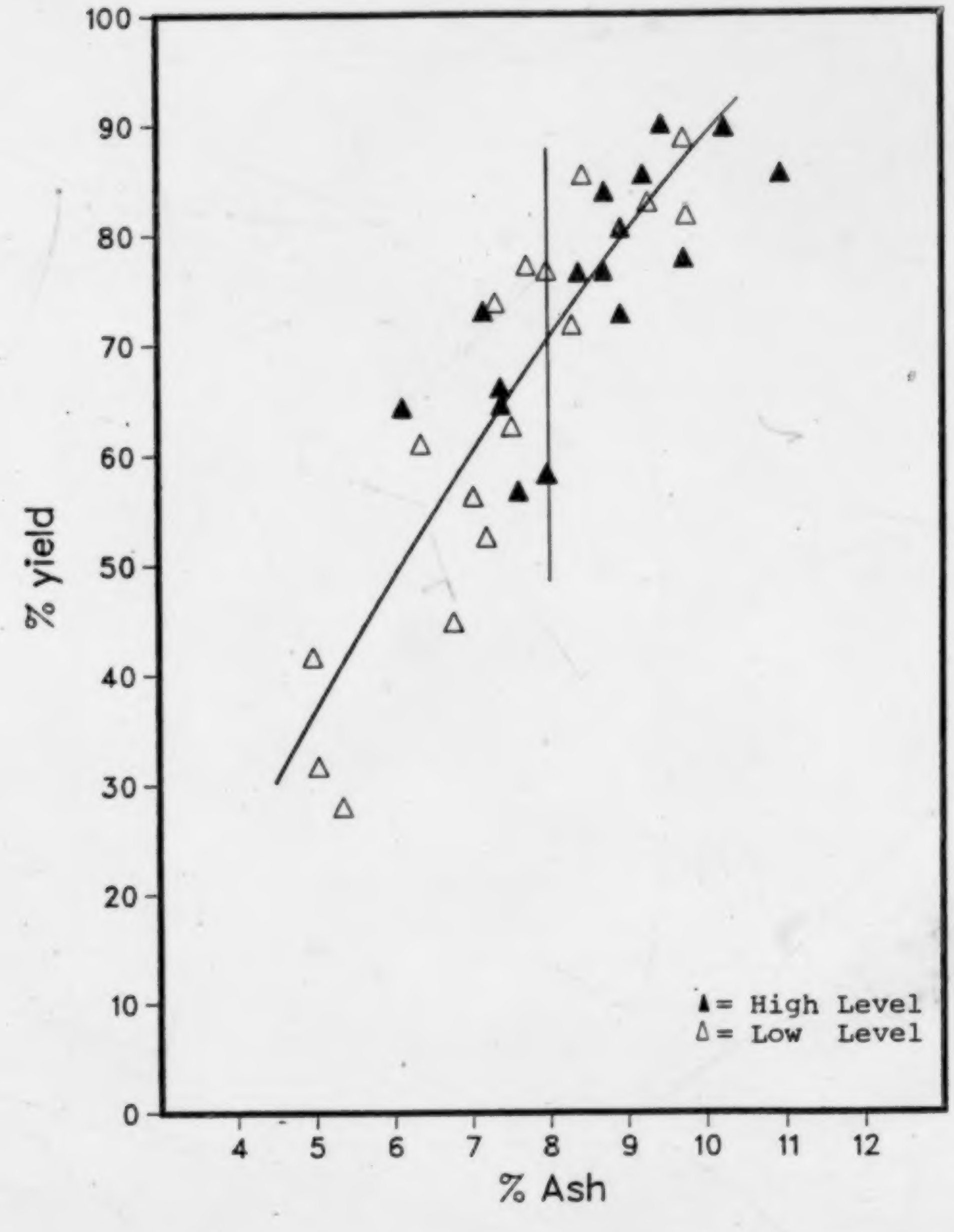

Figure 4.5 Yield-Ash Trends For Frother In The Screening Series

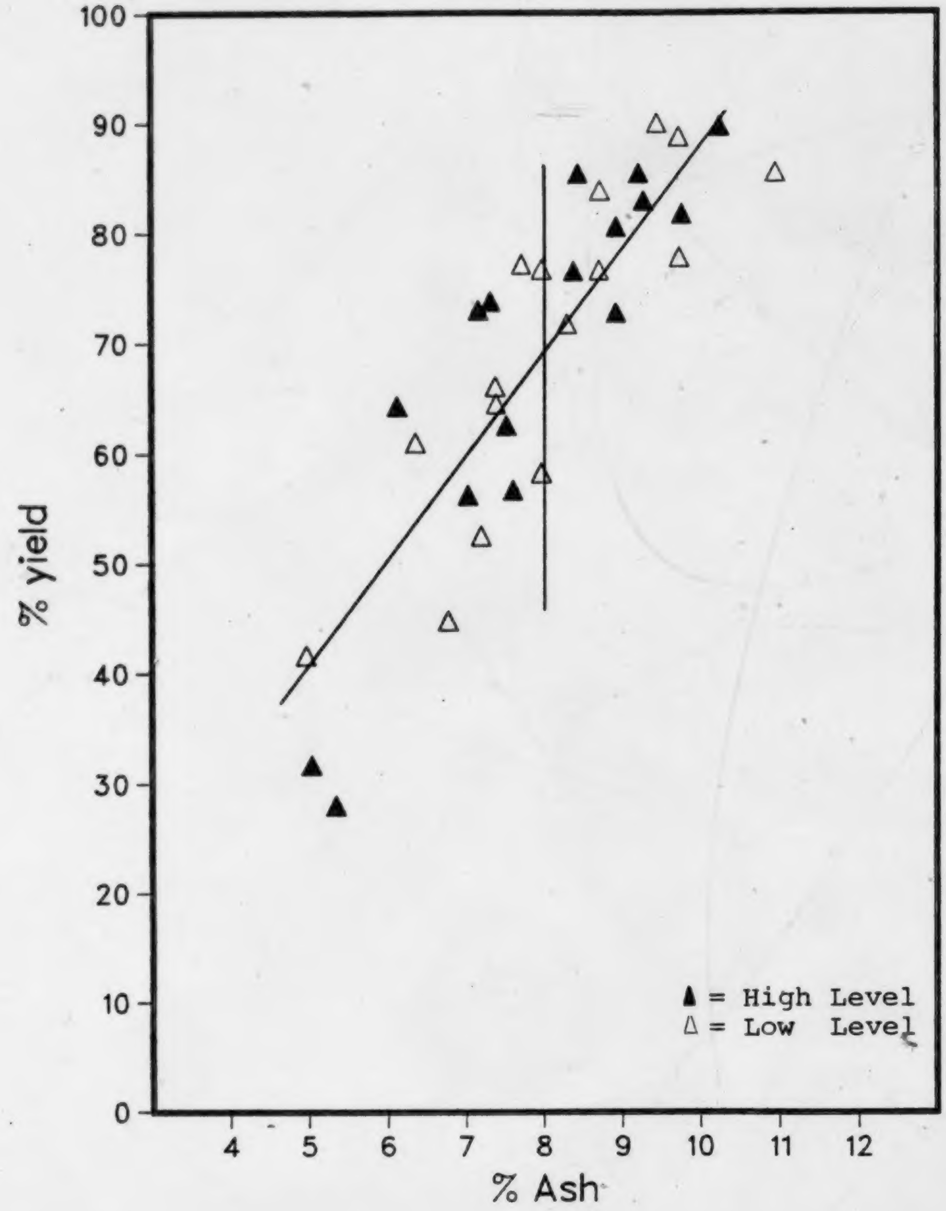

Figure 4.6 Yield-Ash Trends For Conditioning Time In The Screening Series

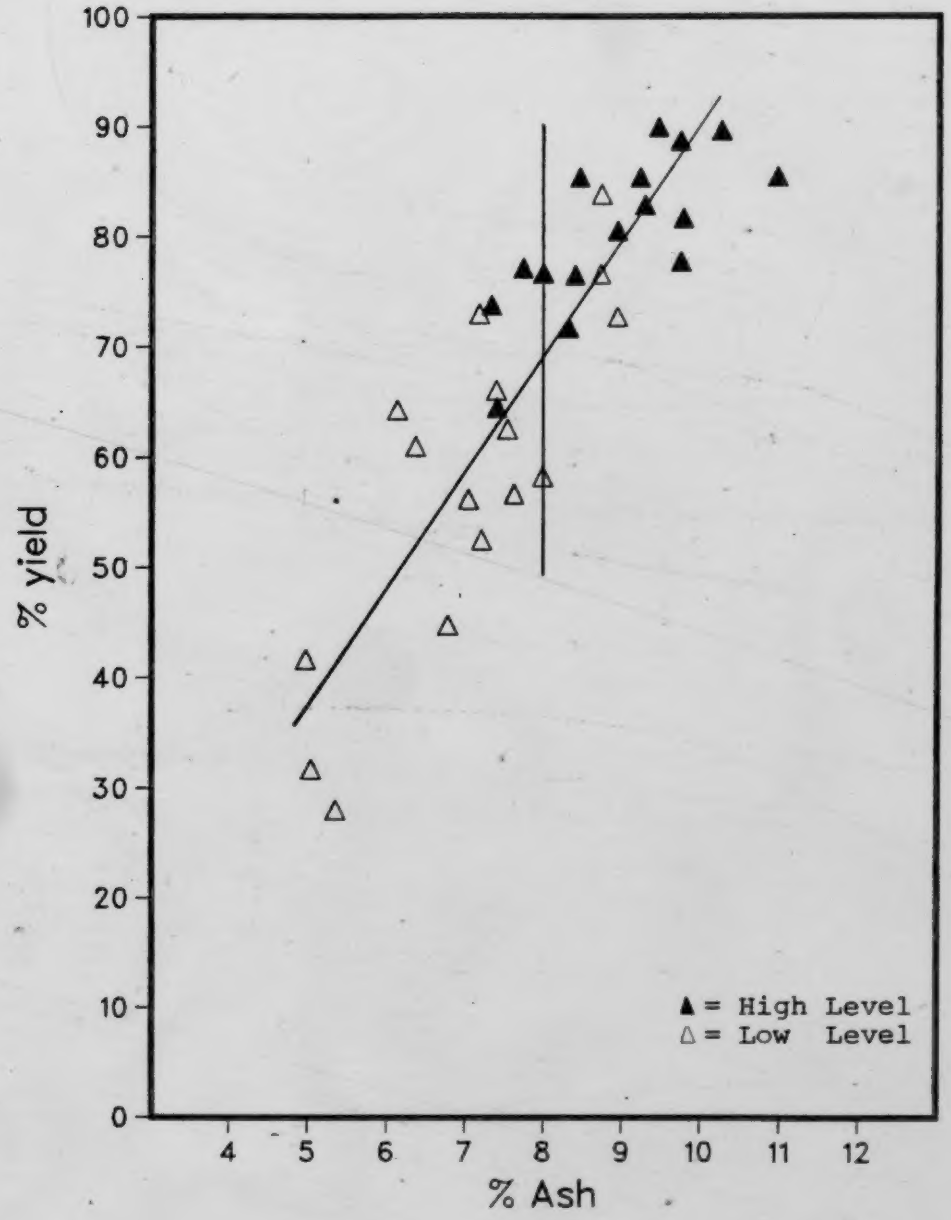

Figure 4.7 Yield-Ash Trends For % Solids In The Screening Series

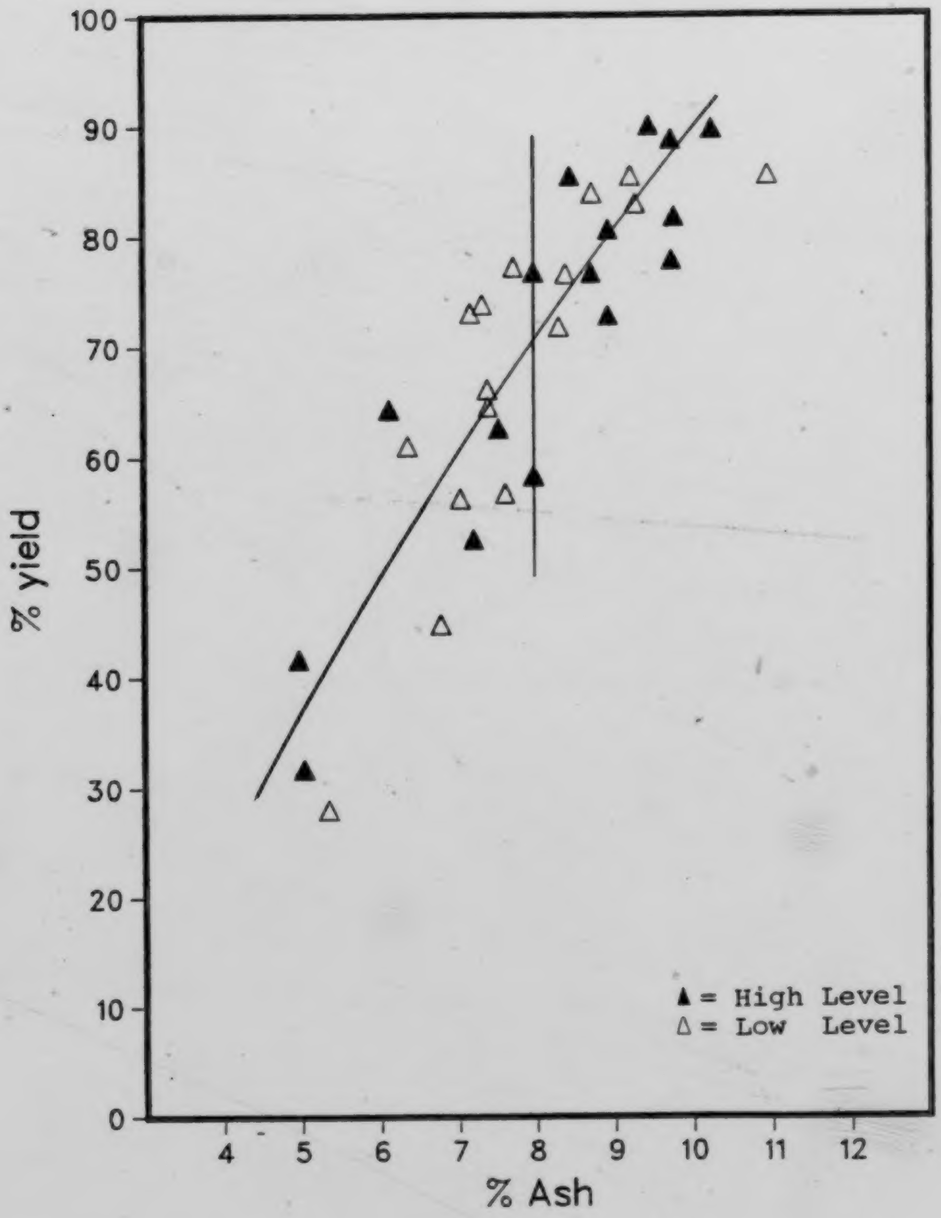

Figure 4.8 Yield-Ash Trends For Impeller Speed In The Screening Series

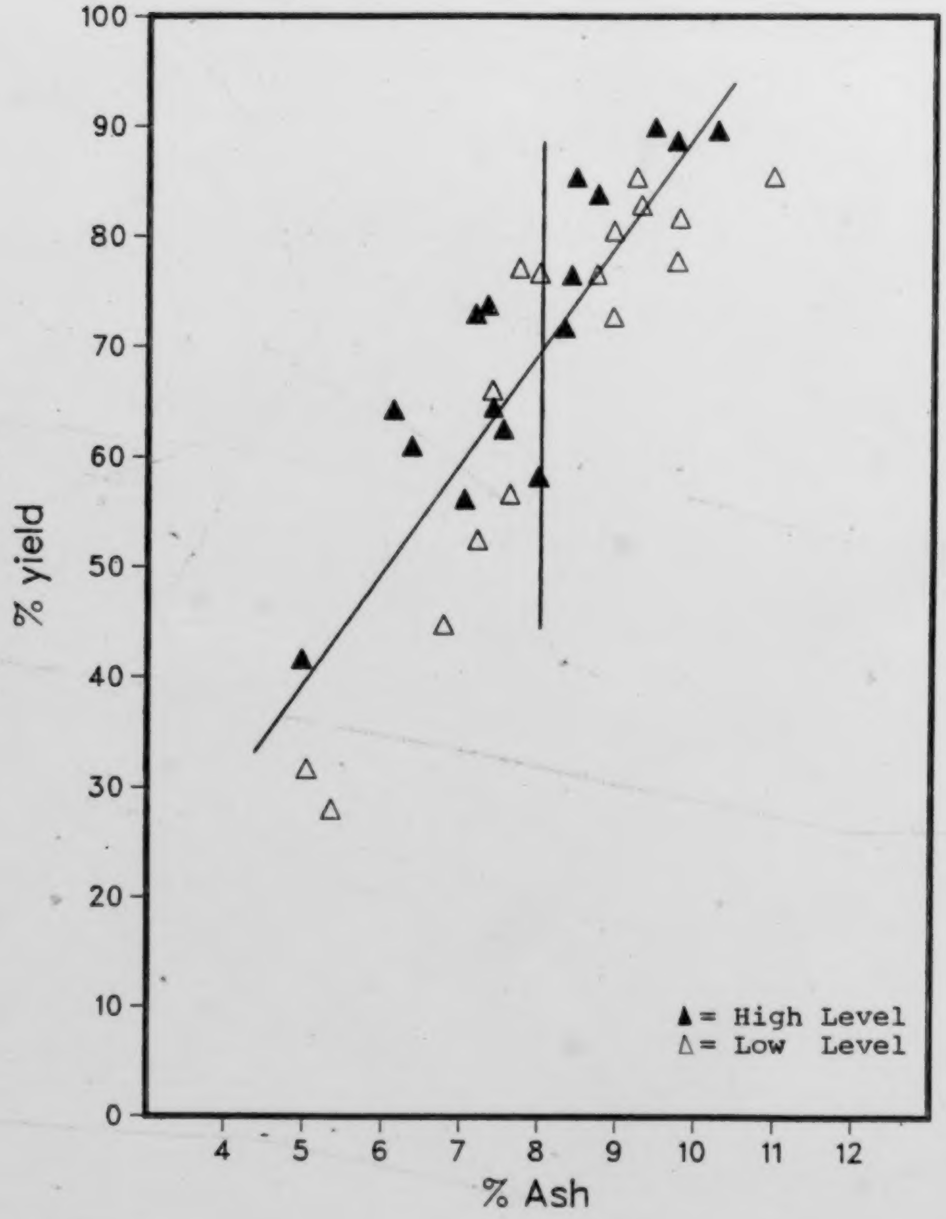

Figure 4.9 Yield-Ash Trends For pH in the Screening Series

specification.

b) **Segregation:** if the data points are segregated with repect to the abscissa, over the range of the yield-ash relationship, then the factor under consideration apparently has the ability to control movement along the curve. As a result it can be considered a process control variable since its manipulation will alter process performance according to some yield-ash curve.

To permit the identification of these two trends two solid lines were drawn on the figures. The vertical line simply divides the data set into two groups of 16 with respect to the abscissa. The sloping line divides the data set in half with respect to some median yield-ash curve. Clearly there is a considerable subjective component in the construction of the latter. Moreover, the presence of a significant trend of one type can often induce a slight presence of the other trend, however, the method does seem reasonable to the author. Without going into detail, the binomial probability density function was used to estimate the probabilities of finding certain combinations of low/high factor levels in a particular data subset (16 observations) by chance alone. Crudely, 4 or fewer observations of a particular level in a data subset indicates significant trending while 5 or 6 indicates slight trending. Using this scale the seven factors are analysed separately below.

Air (X_1): Figure 4.3

Air shows only a slight segregation with no stratification at the levels studied. As a result, it has some potential as a process control variable. Increasing air moves the operating point to higher yield-ash values. The mechanism is thought to be simply the provision of more bubbles which enhances the probability of bubble particle collision.

Collector (X_2): Figure 4.4

Collector shows significant stratification and slight segregation, although the latter is probably the result of the former. In any case, at the higher collector levels studied in the screening series, the yield-ash curve was displaced horizontally to higher ash values (i.e. contamination of the product by small amounts of high ash material). As a result, collector is an optimization variable. The mechanisms responsible for the observed behaviour are thought to be the collection of locked particles and the reduction of froth mobility.

Frother (X_3): Figure 4.5

Frother shows slight segregation and no stratification. It is comparable in behaviour to air and thus is a process control variable. The mechanisms responsible for the observed behaviour are thought to be increasing froth mobility and to a lesser extent, the collecting power of MIBC.

Conditioning Time (X_4): Figure 4.6

Conditioning time shows neither segregation nor stratification and is therefore insignificant at the levels studied.

% Solids (X_5): Figure 4.7

The solids concentration shows significant segregation and some slight stratification which may be the result of the former. While % solids isn't normally thought of as a process control variable it is clear that increasing % solids (while holding the volumetric throughput constant) can have a very pronounced effect on the operating position on the yield-ash curve.

Impeller Speed (X_6): Figure 4.8

Very slight segregation is apparent with no stratification and therefore impeller speed is deemed insignificant at the levels studied.

pH (X_7): Figure 4.9

Slight stratification is apparent with no segregation. This suggests that flotation at higher pH levels may be worth investigation as a part of process optimization, however, it is not as important as collector in this regard.

Summarizing the findings with respect to the typical methods of plant operation, the following conclusions can be drawn:

a) For process control purposes, initial plant investigations should pursue the development of a strategy based upon air and/or frother manipulation.

b) For optimization purposes, initial plant investigations should look at optimizing collector addition and, to a lesser extent, the pulp pH.

c) Inspection of Figure 4.7 and the data of Tables 4.35 and

4.36 at low percent solids shows this to be a critical factor in determining process performance at the levels studied. To obtain reasonable process yields (at acceptable ash levels) requires very careful operation at such low percent solids levels. Certainly any changes which can be brought about to increase the mean solids content of the flotation feed stream above the design level would probably simplify and stabilize the operation appreciably.

The results obtained in this analysis are consistent with the model parameter data obtained in the previous chapters. Of course, one major difference is that only main factor effects are identified here, while there are some significant interactions which have been previously identified. Moreover, the results obtained above also hold for the modelling tests as well, although as Figure 4.2 shows the scatter is reduced considerably in this case making "noise" a relatively important contributor.

The final step in this analysis was to input all of the uncoded data together with the corresponding yield, ash and % solids values to a stepwise multiple linear regression program. The correlations calculated by the program are given in Equations 4.54 through 4.56.

$$\text{Yield} = f(X5, -X35, X3, X17, -X11, X33) \qquad \ldots(4.54)$$

$$r^2 = 0.85$$

$$\text{Ash} = f(X13, X2, X5, X36, -X22, X35, X57, -X33) \quad r^2 = 0.93 \quad \ldots(4.55)$$

$$\text{Solids}(\%) = f(X5, -X55) \quad r^2 = 0.78 \quad \ldots(4.56)$$

These relationships are also consistent with the discussions above, for example, observe that collector will increase ash while not affecting yield.

4.5.3 COMMENTS

The author suggests that Figure 4.2 would be useful to the Gregg River Resources personnel in helping to establish target production values for the individual circuits in the preparation plant. To further assist in this exercise, Table 4.37 has been prepared. This table has the experimental yield-ash data arranged in order of increasing ash. Given some ash value, the experimental conditions which give rise to maximum yield are available through the experimental identification and subsequently from Table 4.1 or 4.27.

4.6 EFFECT OF COARSE PARTICLES ON FLOTATION

The previous flotation tests were carried out on the -212 micron (-65 mesh) feed materials as is the case in plant operation. It may be possible to recover coarse coal by flotation more efficiently than in water-only cyclones. To examin this possiblity, the feed was screened at 600 microns (28 mesh) and then flotated in the laboratory cell.

Table 4.37 The Experimental Yield-Ash Data Arranged In Order Of Increasing Ash

%Yield	%Ash	Series	Test#
22.04	4.94	M	1
41.69	4.97	S	1
31.69	5.04	S	10
37.26	5.13	M	2
22.43	5.35	M	3
28.01	5.35	S	9
43.90	5.49	M	4
51.36	5.74	M	5
50.77	5.79	M	9
55.51	5.84	M	STR 7
51.75	5.85	M	7
53.29	5.93	M	STR 5
55.28	5.97	M	STR 1
64.27	6.13	S	13
60.04	6.15	M	CNTR1
59.14	6.21	M	CNTR4
61.89	6.24	M	CNTR5
60.27	6.25	M	CNTR2
60.68	6.26	M	13
60.95	6.31	M	CNTR3
55.45	6.33	M	11
61.00	6.36	S	2
60.70	6.39	M	STR 4
64.61	6.43	M	STR 3
64.01	6.52	M	CNTR6
65.16	6.60	M	6
56.81	6.61	M	STR 2
60.91	6.68	M	15
44.81	6.78	S	3
63.99	6.78	M	10
65.32	6.90	M	8
66.88	7.00	M	12
56.20	7.03	S	12
73.00	7.16	S	14
52.52	7.20	S	4
75.75	7.26	M	16
73.80	7.32	S	25
72.57	7.32	M	14
66.12	7.38	S	5
66.54	7.39	S	21
62.57	7.53	S	11
74.35	7.57	M	STR 8
56.68	7.61	S	15
77.17	7.72	S	18
78.94	7.82	M	STR 6
76.70	7.98	S	17
58.27	7.98	S	7
71.76	8.30	S	19
76.56	8.38	S	31
85.40	8.44	S	26
79.88	8.53	S	CNTR3
76.61	8.71	S	6
83.86	8.73	S	8
81.16	8.76	S	CNTR5
79.01	8.80	S	CNTR4
80.82	8.86	S	CNTR2
81.03	8.90	S	CNTR1
72.74	8.92	S	16
80.57	8.93	S	29
85.40	9.21	S	30
82.94	9.28	S	28
89.95	9.44	S	22
88.71	9.73	S	20
77.83	9.74	S	23
81.74	9.77	S	27
89.67	10.24	S	32
85.47	10.96	S	24

S = Series of Screening Tests
M = Series of Modelling Tests

Five flotation tests were carried out on the -600 micron material under the *centre point* conditions for the modelling tests. The flotation products were combined correspondingly to produce large product samples, which were then wet screened. Figure 4.10 shows the recovery of solids as a function of time for each size fraction.

Figure 4.10 shows that the equilibrium recoveries are greater than 60% for -65 mesh materials, but the recoveries are less than 60% for +65 mesh materials and decrease with increasing particle size. It is concluded that the flotation of coarser size fraction materials is not an efficient means of separation, supporting the current plant flow sheet in the fine coal circuit.

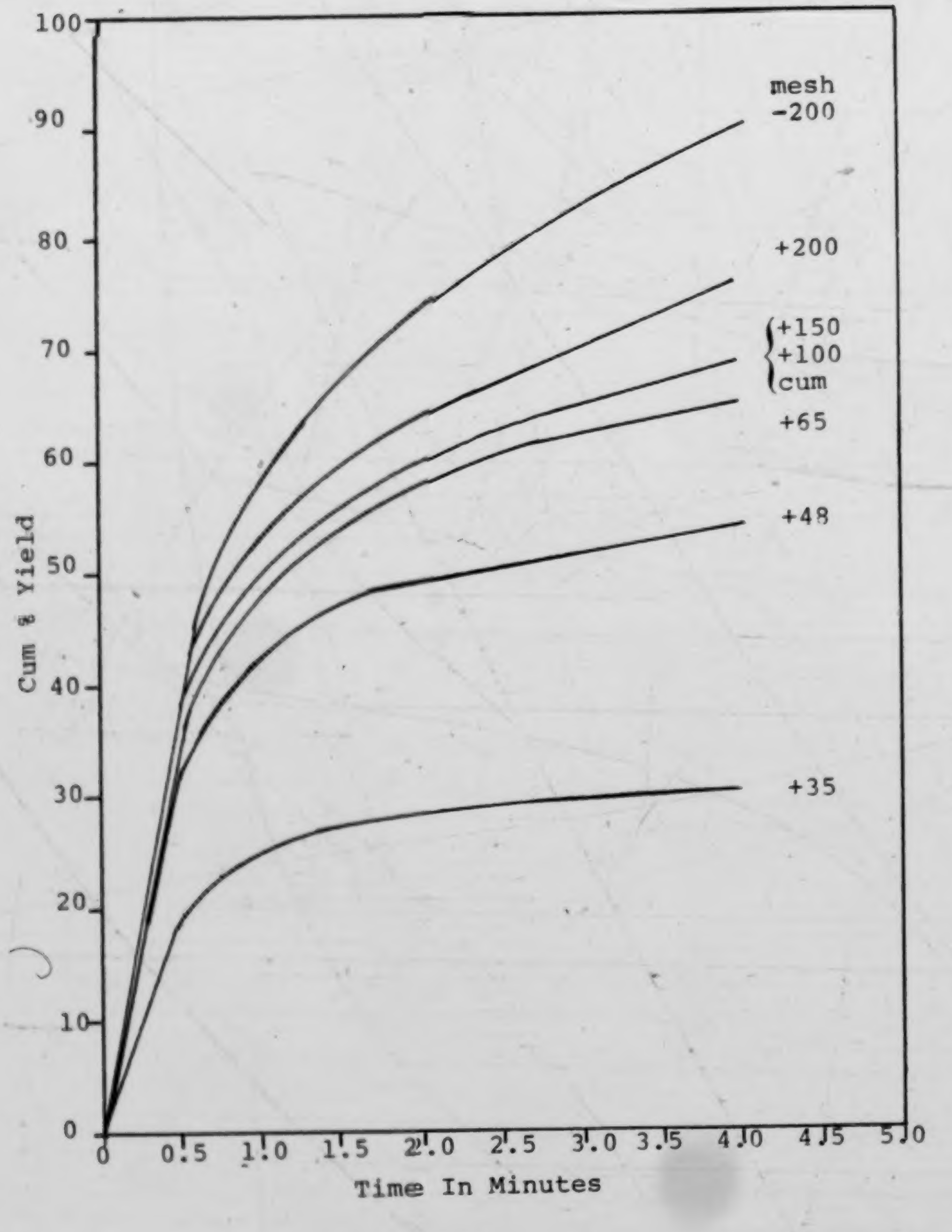

Figure 4.10 Recovery Of Sollids As A Function Of Time For Each Size Fraction

5. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

5.1 CONCLUSIONS

An extensive laboratory investigation of the unoxidized coal flotation system of Gregg River Resources has been completed. Sixty seven batch flotation rate tests were performed in two series. The first was intended to identify those operating factors which had a significant influence on flotation performance and the second was an attempt to quantify these relationships.

The objective of the project was to produce a mathematical model of the coal flotation system which could be used for off-line optimization studies. In the course of deriving the model the operating factors were to be classified as; insignificant at the levels tested, process control variables, or, optimizing variables. This information was intended to assist the operators in rapidly optimizing and controlling the plant flotation circuit.

It was not possible to derive a statistically satisfying mathematical model of the coal flotation system. The problem relates to the experimental error which is contained in the flotation rate data. Although this error component was minimized by using a semi-automatic flotation cell, it was sufficient to introduce enough uncertainty in the flotation model parameters that attempts to correlate these parameters with the operating factors were unsuccessful. It was concluded that even had the tests been performed with the best available flotation cell this would still have been the case.

As a result of this unfortunate circumstance, a more qualitative approach toward data rationallization was also taken with a quantitative analysis. Based on the flotation model parameter linear functional relationships derived in both the screening and modelling test series, and the novel method of analysis introduced in sections 4.5 and 4.6, the following conclusions are drawn:

1) The flotation of the Gregg River Resources coal was shown to be essentially a first-order process.
2) The compound first order model (Equation 2.9) was found to give the best overall fit (with its statistical limitations).
3) The relationship between the standard error of the parameters and the standard deviation of the data was observed to be linear.
4) For the compound first order model, the variation in the standard deviation of the data had no apparent effect on the standard error of ϕ, but the values for Kf and Ks were affected.
5) Of the seven factors investigated aeration rate, collector addition, frother addition and the percent solids in the flotation feed were judged to be important in so far as they affect flotation performance. Conditioning time, impeller speed and pulp pH were judged to be insignificant at the

levels studied.

6) Of the four significant factors the collector addition was classified as an optimizing variable. A minimum operating level must be established in the plant which will ensure hydrophobicity while minimizing the floatability of the high ash middling particles.

7) Of the four significant factors aeration rate and frother addition were classified as process control variables. Manipulation of one or both of these factors should provide an effective means of controlling the operating point on the yield-ash curve for the process. Automatic control could be investigated once the necessary sensors are commercially available.

8) The last of the significant factors, the percent solids concentration in the feed, also behaves in the manner of a process control variable. That is, increasing this attribute will generally cause an increase in the yield and ash content of the flotation product. The system appears to be quite sensitive to this factor, especially at the lower values which are typical of the plant design material balance. Any circuit modification which could be made to increase the mean level of this factor would undoubtedly simplify process operation.

9) Of the insignificant factors the following may be

stated:

-Conditioning time does not appear important for the coal studied, however, slighlty oxidized coal or simply more difficult coals may require conditioning with collector prior to flotation.

-Impeller speed is important only in so far as a level is specified which ensures mixing and an appropriate bubble size distribution while minimizing particle entrainment in the froth column.

-Pulp pH may have a secondary effect as an optimizing variable, perhaps when slightly oxidized coal is being treated.

10) At the factor levels tested, the individual size fractions behave in an identical manner.

11) The flotation feed could not be modified to include the -600 micron materials from the current -212 micron materials, which are the present flotation feed used in the Gregg River Resources preparation plant.

5.2 RECOMMENDATIONS FOR FURTHER WORK

The following aspects of coal flotation are suggested as topics of future investigations:

1) The flotation cell should be improved to reduce the experimental error. This would permit the development of more accurate models to represent the flotation system.

2) A computer simulator should be developed using the compound first order model with suitable representation of the transport character of the industrial scale flotation cell banks. This would give "some" ideas about the Gregg River Resources flotation system and would help train flotation operators. The process control strategy and off-line optimization to identify the optimal flotation operating conditions could also be carried out.
3) The levels of operating variables for the flotation system should be evaluated at the pilot and plant scales.

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7. APPENDIX I

Raw Data For The Screening Tests, The Size Fraction Studies On The Screening Tests and The Modelling Tests

The Screening Tests

```
                      ********************************
                      *   BATCH FLOTATION STUDIES    *
                      *   ON GREGG RIVER RESOURCES   *
                      *          FINE COAL           *
                      ********************************


IDENTIFICATION: BLOCK#  4     TEST#  1     DATE: FEB. 7, 1983          TYPE  SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT.     -1       0.2        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS     -1       3.0        %
RPM           1       1250.0
PH            1       8.6
----------------------------------------

MISCELLANEOUS DATA. TORQUE(G)= 110.0     RESERVOIR WATER ADDED(G)= 282.0
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                    % SOLIDS   ASH        SOLIDS
-----------------------------------------------------------------------
 0.50      22.49      4.69     23.04      22.49       4.69      23.04
 1.00      11.26      4.79     18.58      33.75       4.72      21.33
 2.00       7.80      5.05     16.15      41.55       4.76      20.12
 4.00       4.56      5.21      6.45      46.11       4.83      16.84
 8.00       3.80     10.06      2.50      49.91       5.22      11.63
-----------------------------------------------------------------------
TAILINGS  50.09     17.78       1.70      N/A        N/A        N/A
-----------------------------------------------------------------------
FEED     100.00     11.54       2.98     100.00      11.54      N/A
-----------------------------------------------------------------------
                                          MEASURED: 11.76
                                          --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      24.25      9.06       2.29
 1.00      35.39     13.69       3.80
 2.00      44.77     17.08       5.04
 4.00      49.66     19.12       7.05
 8.00      53.53     22.41      11.58
----------------------------------------
```

```
                      ********************************
                      *   BATCH FLOTATION STUDIES    *
                      *   ON GREGG RIVER RESOURCES   *
                      *          FINE COAL           *
                      ********************************


IDENTIFICATION  BLOCK#  3     TEST#  2     DATE:   JAN. 7,1983          TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT      -1       0.2        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS     -1       3.0        %
RPM          -1       850.0
PH            1       8.6
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 741.9
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                    % SOLIDS   ASH        SOLIDS
-----------------------------------------------------------------------
 0.50      38.06      5.73     22.39      38.06       5.73      22.39
 1.00      11.93      6.71     17.20      50.00       5.97      20.89
 2.00       9.80      7.18      6.27      59.80       6.17      16.71
 4.00       8.97      8.54      4.78      68.76       6.48      12.62
 8.00       5.44     11.39      2.33      74.21       6.84       9.53
-----------------------------------------------------------------------
TAILINGS  25.79     28.05       0.79      N/A        N/A        N/A
-----------------------------------------------------------------------
FEED     100.00     11.86       2.48     100.00      11.86      N/A
-----------------------------------------------------------------------
                                          MEASURED: 11.93
                                          --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      40.71     18.41       3.36
 1.00      53.34     25.15       4.82
 2.00      63.66     31.08       7.59
 4.00      72.96     37.56      12.12
 8.00      78.44     42.76      17.94
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  3     TEST#  3     DATE:   JAN. 28, 1983          TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR           -1       3.0        L/MIN.
COLLECT        1       3.0        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT        -1       1.0        MINUTES
% SOLIDS      -1       3.0        %
RPM           -1       850.0
PH            -1       7.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  72.0      RESERVOIR WATER ADDED(G)=1274.4
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %       WT. %       CUM.       CUM.        CUM
INCREMENT  SOLIDS %  ASH         SOLIDS      RECOVERED  WT. %       WT. %
(MIN.)                                       % SOLIDS   ASH         SOLIDS
-----------------------------------------------------------------------------
 0.50       30.86        6.34      29.10      30.86        6.34      29.10
 1.00        9.60        6.36      14.27      40.46        6.34      23.34
 2.00        2.80       10.14       2.83      43.26        6.59      15.90
 4.00        5.65       10.54       2.65      48.91        7.04      10.08
 8.00        5.76        8.33       4.32      54.67        7.18       8.84
-----------------------------------------------------------------------------
TAILINGS    45.33       17.57       1.27      N/A          N/A        N/A
-----------------------------------------------------------------------------
FEED       100.00       11.90       2.38     100.00       11.90       N/A
-----------------------------------------------------------------------------
                                             MEASURED: 11.81
                                             -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS   ASH         WATER
TIME
----------------------------------------
 0.50       32.81      16.44        1.83
 1.00       43.01      21.57        3.24
 2.00       45.87      23.96        5.58
 4.00       51.60      28.96       10.64
 8.00       57.59      32.99       13.74
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION  BLOCK#  3     TEST#  4     DATE:   JAN. 28, 1983          TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR            1       7.0        L/MIN.
COLLECT        1       3.0        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT        -1       1.0        MINUTES
% SOLIDS      -1       3.0        %
RPM            1       1250.0
PH            -1       7.8
----------------------------------------

MISCELLANEOUS DATA  TORQUE(G)=  96.0      RESERVOIR WATER ADDED(G)= 848.3
------------------

EXPERIMENTAL RESULTS
---------------------
FLOAT      RECOVERED WT. %       WT. %       CUM.       CUM.        CUM
INCREMENT  SOLIDS %  ASH         SOLIDS      RECOVERED  WT. %       WT. %
(MIN.)                                       % SOLIDS   ASH         SOLIDS
-----------------------------------------------------------------------------
 0.50       32.36        6.65      24.21      32.36        6.65      24.21
 1.00        9.57        7.28      18.88      41.93        6.79      22.75
 2.00        8.09        8.20      13.96      50.02        7.02      20.65
 4.00       11.69        8.67       9.05      61.71        7.33      16.61
 8.00        5.84       11.08       3.30      67.56        7.66      12.31
-----------------------------------------------------------------------------
TAILINGS    32.44       21.28       1.06      N/A          N/A        N/A
-----------------------------------------------------------------------------
FEED       100.00       11.92       2.76     100.00       11.92       N/A
-----------------------------------------------------------------------------
                                             MEASURED: 11.76
                                             -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS   ASH         WATER
TIME
----------------------------------------
 0.50       34.30      18.05        2.87
 1.00       44.37      23.89        4.04
 2.00       52.80      29.46        5.46
 4.00       64.93      37.97        8.79
 8.00       70.82      43.40       13.66
----------------------------------------
```

```
               ********************************
               *  BATCH FLOTATION STUDIES     *
               *  ON GREGG RIVER RESOURCES    *
               *          FINE COAL           *
               ********************************

IDENTIFICATION  BLOCK#  3     TEST#  5     DATE:   JAN. 27, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
---------------------------------------
AIR          -1       3.0        L/MIN
COLLECT      -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS     -1       3.0        %
RPM          -1       950.0
PH           -1       7.8
---------------------------------------

MISCELLANEOUS DATA:  TORQUE(G)=  72.0     RESERVOIR WATER ADDED(G)=1049.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
-----------------------------------------------------------------------------
 0.50       43.93      6.71      27.39      43.93       6.71       27.39
 1.00       15.89      7.09      22.72      59.82       6.81       25.97
 2.00        5.40     10.17       5.69      65.21       7.09       20.06
 4.00        5.67     10.76       4.42      70.88       7.38       15.64
 8.00        5.12     10.70       4.19      76.00       7.61       13.21
-----------------------------------------------------------------------------
TAILINGS    24.00     23.68       0.70      N/A         N/A         N/A
-----------------------------------------------------------------------------
FEED       100.00     11.64       2.51     100.00      11.64        N/A
-----------------------------------------------------------------------------
                                           MEASURED:  11.62
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       46.38     25.32       3.00
 1.00       63.09     35.00       4.38
 2.00       68.57     39.72       6.70
 4.00       74.30     44.96       9.85
 8.00       79.47     49.67      12.87
----------------------------------------
```

```
               ********************************
               *  BATCH FLOTATION STUDIES     *
               *  ON GREGG RIVER RESOURCES    *
               *          FINE COAL           *
               ********************************

IDENTIFICATION  BLOCK#  3     TEST#  6     DATE    JAN. 27, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
---------------------------------------
AIR           1       7.0        L/MIN
COLLECT      -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS     -1       3.0        %
RPM           1       1250.0
PH           -1       7.8
---------------------------------------

MISCELLANEOUS DATA:  TORQUE(G)=  98.0     RESERVOIR WATER ADDED(G)=1001.6
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM         CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
-----------------------------------------------------------------------------
 0.50       46.37      7.52      21.18      46.37       7.52       21.18
 1.00       15.45      8.61      18.31      61.82       7.79       20.38
 2.00       15.71     11.14       7.94      77.53       8.47       15.47
 4.00        6.53     11.17       4.09      84.06       8.68       12.72
 8.00        3.72     15.75       1.52      87.78       8.98        8.69
-----------------------------------------------------------------------------
TAILINGS    12.22     30.76       0.36      N/A         N/A         N/A
-----------------------------------------------------------------------------
FEED       100.00     11.71       2.34     100.00      11.71        N/A
-----------------------------------------------------------------------------
                                           MEASURED:  11.78
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       48.57     29.77       4.14
 1.00       64.57     41.13       5.79
 2.00       80.38     56.07      10.18
 4.00       86.95     62.29      13.83
 8.00       90.50     67.30      19.62
----------------------------------------
```

```
                    ******************************
                    *  BATCH FLOTATION STUDIES   *
                    *  ON GREGG RIVER RESOURCES  *
                    *         FINE COAL          *
                    ******************************

IDENTIFICATION: BLOCK#  3     TEST#  7     DATE:   JAN. 6, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR          -1         3.0       L/MIN
COLLECT       1         3.0       L/TONNE
FROTHER       1         0.35      L/TONNE
CONDIT.      -1         1.0       MINUTES
% SOLIDS     -1         3.0       %
RPM           1         1250.0
PH            1         8.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 110.0     RESERVOIR WATER ADDED(G)= 862.3
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT       RECOVERED WT. %       WT. %       CUM.         CUM          CUM
INCREMENT  SOLIDS %  ASH          SOLIDS      RECOVERED  WT. %          WT. %
(MIN.)                                        % SOLIDS   ASH            SOLIDS
--------------------------------------------------------------------------------
 0.50        45.45      7.46       21.08       45.45       7.46        21.08
 1.00         6.69      7.76        6.31       52.14       7.50        16.21
 2.00         4.86      9.59        2.15       57.00       7.68        11.99
 4.00         5.13      9.93        3.17       62.13       7.86         8.75
 8.00         9.29      9.13        4.27       71.42       8.03         8.40
--------------------------------------------------------------------------------
TAILINGS     28.58     19.64        0.87       N/A         N/A         N/A
--------------------------------------------------------------------------------
FEED        100.00     11.52        2.42      100.00      11.52        N/A
--------------------------------------------------------------------------------
                                              MEASURED: 11.69
                                              ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH         WATER
TIME
----------------------------------------
 0.50        47.53     29.44       4.23
 1.00        54.51     33.95       6.70
 2.00        59.47     37.99      10.40
 4.00        64.70     42.42      14.29
 8.00        74.24     49.76      19.34
----------------------------------------
```

```
                    ******************************
                    *  BATCH FLOTATION STUDIES   *
                    *  ON GREGG RIVER RESOURCES  *
                    *         FINE COAL          *
                    ******************************

IDENTIFICATION: BLOCK#  2     TEST#  8     DATE    JAN. 6,1983           TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR           1         7.0       L/MIN
COLLECT       1         3.0       L/TONNE
FROTHER       1         0.35      L/TONNE
CONDIT.      -1         1.0       MINUTES
% SOLIDS     -1         3.0       %
RPM          -1         850.0
PH            1         8.8
----------------------------------------

MISCELLANEOUS DATA  TORQUE(G)=  72.0     RESERVOIR WATER ADDED(G)= 863.6
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT       RECOVERED WT. %       WT. %       CUM.         CUM          CUM
INCREMENT  SOLIDS %  ASH          SOLIDS      RECOVERED  WT. %          WT. %
(MIN.)                                        % SOLIDS   ASH            SOLIDS
--------------------------------------------------------------------------------
 0.50        56.44      7.29       22.60       56.44       7.29        22.80
 1.00        16.96      9.88       15.11       73.40       7.88        20.28
 2.00         9.88     11.83        5.86       83.28       8.35        16.46
 4.00         7.93     11.62        5.77       91.21       8.64        14.17
 8.00         2.11     22.36        1.06       93.32       8.95        11.08
--------------------------------------------------------------------------------
TAILINGS      6.68     45.81        0.20       N/A         N/A         N/A
--------------------------------------------------------------------------------
FEED        100.00     11.60        2.41      100.00      11.60        N/A
--------------------------------------------------------------------------------
                                              MEASURED: 11.78
                                              ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH         WATER
TIME
----------------------------------------
 0.50        59.20     35.46       4.77
 1.00        76.49     49.81       7.12
 2.00        86.34     59.98      10.43
 4.00        94.27     67.93      13.62
 8.00        96.12     71.99      16.47
----------------------------------------
```

```
*********************************
*   BATCH FLOTATION STUDIES     *
*   ON GREGG RIVER RESOURCES    *
*            FINE COAL          *
*********************************


IDENTIFICATION: BLOCK#  3     TEST#  9     DATE:   JAN. 28, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR           -1       3.0        L/MIN.
COLLECT       -1       0.2        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT.        1       5.0        MINUTES
% SOLIDS      -1       3.0        %
RPM           -1       850.0
PH            -1       7.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  75.0     RESERVOIR WATER ADDED(G)= 830.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %     WT. %      CUM.        CUM.        CUM.
INCREMENT  SOLIDS %  ASH       SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                    % SOLIDS    ASH         SOLIDS
----------------------------------------------------------------------------
 0.50       13.78      4.34     25.18      13.78       4.34       25.18
 1.00        7.54      5.51      9.31      21.32       4.75       15.71
 2.00        5.63      7.01      4.82      26.95       5.22       10.67
 4.00        5.71      6.11      5.61      32.65       5.38        9.22
 8.00        4.36      6.85      4.07      37.01       5.55        8.02
----------------------------------------------------------------------------
TAILINGS    62.99     15.45      1.82      N/A         N/A         N/A
----------------------------------------------------------------------------
FEED       100.00     11.76      2.67     100.00      11.76        N/A
----------------------------------------------------------------------------
                                          MEASURED: 11.74
                                          --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
 0.50       14.94      5.09       1.12
 1.00       23.02      8.62       3.14
 2.00       28.85     11.97       5.19
 4.00       35.02     14.94       8.83
 8.00       39.62     17.47      11.65
-----------------------------------------
```

```
*********************************
*   BATCH FLOTATION STUDIES     *
*   ON GREGG RIVER RESOURCES    *
*            FINE COAL          *
*********************************


IDENTIFICATION: BLOCK#  3     TEST# 10     DATE:   JAN. 29, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR            1       7.0        L/MIN.
COLLECT       -1       0.2        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT.        1       5.0        MINUTES
% SOLIDS      -1       3.0        %
RPM            1       1250.0
PH            -1       7.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  83.0     RESERVOIR WATER ADDED(G)= 531.3
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %     WT. %      CUM.        CUM.        CUM.
INCREMENT  SOLIDS %  ASH       SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                    % SOLIDS    ASH         SOLIDS
----------------------------------------------------------------------------
 0.50       11.88      4.35     19.17      11.88       4.35       19.17
 1.00       10.48      4.36     19.43      22.36       4.36       19.29
 2.00        7.34      5.18     10.65      29.70       4.56       16.07
 4.00        8.84      8.05      3.87      38.54       5.36        9.33
 8.00        5.25      9.26      2.92      43.79       5.83        7.38
----------------------------------------------------------------------------
TAILINGS    56.21     16.18      1.81      N/A         N/A         N/A
----------------------------------------------------------------------------
FEED       100.00     11.69      2.70     100.00      11.69        N/A
----------------------------------------------------------------------------
                                          MEASURED: 11.74
                                          --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
 0.50       12.87      4.42       1.39
 1.00       24.22      8.33       2.59
 2.00       32.10     11.58       4.30
 4.00       41.31     17.67      10.39
 8.00       46.70     21.82      15.24
-----------------------------------------
```

```
                 ********************************
                 *  BATCH FLOTATION STUDIES     *
                 *  ON GREGG RIVER RESOURCES    *
                 *          FINE COAL           *
                 ********************************

IDENTIFICATION  BLOCK#  4     TEST# 11     DATE:   FEB. 8,1983            TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
-----------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR           -1       3.0        L/MIN
COLLECT        1       3.0        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT.        1       5.0        MINUTES
% SOLIDS      -1       3.0        %
RPM            1       1250.0
PH             1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 112.0     RESERVOIR WATER ADDED(G)= 460.0
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT       RECOVERED WT. %      WT. %       CUM.        CUM.        CUM
INCREMENT   SOLIDS %  ASH        SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                       % SOLIDS    ASH         SOLIDS
--------------------------------------------------------------------------------
  0.50      36.81       7.06     20.37       36.81        7.06       20.37
  1.00      16.34       7.13     20.46       53.15        7.08       20.40
  2.00       9.28       7.86     12.70       62.43        7.21       18.71
  4.00       5.51       9.37      4.83       67.95        7.38       15.17
  8.00       4.44      10.33      2.82       72.39        7.56       12.07
--------------------------------------------------------------------------------
TAILINGS    27.61      21.26      0.92       N/A         N/A         N/A
--------------------------------------------------------------------------------
FEED       100.00      11.58      2.77      100.00       11.58       N/A
--------------------------------------------------------------------------------
                                             MEASURED: 11.62
                                             --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS   ASH        WATER
TIME
-----------------------------------------
  0.50      38.68      22.49       4.10
  1.00      55.64      32.55       5.92
  2.00      65.52      38.85       7.74
  4.00      71.18      43.31      10.84
  8.00      75.68      47.27      15.05
-----------------------------------------




                 ********************************
                 *  BATCH FLOTATION STUDIES     *
                 *  ON GREGG RIVER RESOURCES    *
                 *          FINE COAL           *
                 ********************************

IDENTIFICATION  BLOCK#  3     TEST# 12     DATE   JAN. 8,1983             TYPE    SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS
-----------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR            1       7.0        L/MIN
COLLECT        1       3.0        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT.        1       5.0        MINUTES
% SOLIDS      -1       3.0        %
RPM           -1       950.0
PH             1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  60.0     RESERVOIR WATER ADDED(G)= 281.5
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT       RECOVERED WT. %      WT. %       CUM.        CUM.        CUM
INCREMENT   SOLIDS %  ASH        SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                       % SOLIDS    ASH         SOLIDS
--------------------------------------------------------------------------------
  0.50      37.71       6.53     24.47       37.71        6.53       24.47
  1.00       7.09       6.75      8.25       44.80        6.56       18.67
  2.00       8.61       7.53      8.08       53.41        6.72       15.40
  4.00      13.64       8.78      9.08       67.05        7.14       13.49
  8.00       9.81       8.46      5.83       76.86        7.31       11.43
--------------------------------------------------------------------------------
TAILINGS    23.04      26.87      0.79       N/A         N/A         N/A
--------------------------------------------------------------------------------
FEED       100.00      11.78      2.77      100.00       11.78       N/A
--------------------------------------------------------------------------------
                                             MEASURED: 11.71
                                             --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS   ASH        WATER
TIME
-----------------------------------------
  0.50      38.95      20.91       3.32
  1.00      47.45      24.87       5.57
  2.00      56.47      30.48       8.37
  4.00      70.57      40.65      12.28
  8.00      80.85      47.77      17.00
-----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION  BLOCK#  3     TEST# 13     DATE:   JAN. 10,1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS
-----------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
-----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT      -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS     -1       3.0        %
RPM           1       1250.0
PH            1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 103.0     RESERVOIR WATER ADDED(G)= 709.9
------------------

EXPERIMENTAL RESULTS
--------------------
FLOAT     RECOVERED WT. %      WT. %     CUM.        CUM.        CUM.
INCREMENT SOLIDS %  ASH        SOLIDS    RECOVERED   WT. %       WT. %
(MIN.)                                   % SOLIDS    ASH         SOLIDS
---------------------------------------------------------------------------
 0.50      32.95       5.61     22.02     32.95       5.61        22.02
 1.00      22.88       5.90     20.76     55.83       5.73        21.48
 2.00       6.99       7.52      7.78     62.82       5.93        17.97
 4.00       7.65       7.86      5.03     70.47       6.14        14.04
 8.00       3.00      10.21      2.02     73.47       6.31        11.30
---------------------------------------------------------------------------
TAILINGS   26.53      26.08      0.84     N/A         N/A         N/A
---------------------------------------------------------------------------
FEED      100.00      11.74      2.62    100.00      11.74        N/A
---------------------------------------------------------------------------
                                         MEASURED: 11.93
                                         --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      35.24     15.75       3.14
 1.00      59.63     27.26       5.50
 2.00      65.95     31.73       7.72
 4.00      74.94     35.85      11.62
 8.00      77.99     39.47      15.54
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION  BLOCK#  3     TEST# 14     DATE:   JAN. 10, 1983         TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS
-----------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
-----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT      -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS     -1       3.0        %
RPM          -1       950.0
PH            1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  88.0     RESERVOIR WATER ADDED(G)= 503.2
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT     RECOVERED WT. %      WT. %     CUM.        CUM.        CUM.
INCREMENT SOLIDS %  ASH        SOLIDS    RECOVERED   WT. %       WT. %
(MIN.)                                   % SOLIDS    ASH         SOLIDS
---------------------------------------------------------------------------
 0.50      40.58       6.11     22.15     40.58       6.11        22.15
 1.00      19.74       7.07     18.82     60.31       6.42        20.84
 2.00      11.08       9.12     11.65     71.39       6.84        18.63
 4.00      10.44       9.50      6.33     81.83       7.18        14.93
 8.00       3.85      12.81      2.13     85.69       7.43        11.79
---------------------------------------------------------------------------
TAILINGS   14.31      35.80      0.46     N/A         N/A         N/A
---------------------------------------------------------------------------
FEED      100.00      11.67      2.62    100.00      11.67        N/A
---------------------------------------------------------------------------
                                         MEASURED: 11.88
                                         --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      43.13     21.23       3.63
 1.00      63.90     33.19       6.12
 2.00      75.29     41.84       8.37
 4.00      86.00     50.34      12.52
 8.00      89.80     54.57      17.28
----------------------------------------
```

```
                    ********************************
                    *  BATCH FLOTATION STUDIES     *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     TEST# 15     DATE:   JAN. 28, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
-----------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
--------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT.      1       3.0        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS     -1       3.0        %
RPM          -1       950.0
PH           -1       7.8
--------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  72.0     RESERVOIR WATER ADDED(G)= 758.5
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.        CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                    % SOLIDS   ASH         SOLIDS
---------------------------------------------------------------------
 0.50      32.08       6.90     27.97     32.08        6.90      27.97
 1.00      13.56       7.53     17.52     45.64        7.09      23.78
 2.00       6.40       8.19      7.34     52.04        7.22      18.63
 4.00      15.74       8.23     14.51     67.78        7.46      17.48
 8.00      13.35       9.00     13.04     81.13        7.71      16.56
---------------------------------------------------------------------
TAILINGS  18.87      26.39       0.59     N/A        N/A         N/A
---------------------------------------------------------------------
FEED     100.00      11.52       2.69    100.00      11.52       N/A
---------------------------------------------------------------------
                                          MEASURED: 11.80
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
--------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
--------------------------------------
 0.50      33.75     19.22       2.29
 1.00      47.93     28.09       4.05
 2.00      54.56     32.64       6.29
 4.00      70.89     43.86       8.85
 8.00      84.62     54.31      11.32
--------------------------------------
```

```
                    ********************************
                    *  BATCH FLOTATION STUDIES     *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     TEST# 16     DATE:   JAN  29, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
-----------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
--------------------------------------
AIR           1       7.0        L/MIN
COLLECT.      1       3.0        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS     -1       3.0        %
RPM           1       1250.0
PH           -1       7.8
--------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  98.0     RESERVOIR WATER ADDED(G)=1137.6
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.        CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                    % SOLIDS   ASH         SOLIDS
---------------------------------------------------------------------
 0.50      45.99       8.21     20.24     45.99        8.21      20.24
 1.00      16.32       9.19     18.35     62.31        8.47      19.70
 2.00       8.30       9.41     13.88     70.62        8.58      18.78
 4.00      10.79       9.85     11.99     81.40        8.75      17.47
 8.00       6.08      11.27      4.18     87.48        8.92      14.30
---------------------------------------------------------------------
TAILINGS  12.51      29.62       0.36     N/A        N/A         N/A
---------------------------------------------------------------------
FEED     100.00      11.65       2.43    100.00      11.65       N/A
---------------------------------------------------------------------
                                          MEASURED: 11.79
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
--------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
--------------------------------------
 0.50      47.78     32.42       4.52
 1.00      64.56     45.29       6.33
 2.00      73.07     51.99       7.62
 4.00      84.08     61.11       9.59
 8.00      90.19     67.00      13.07
--------------------------------------
```

```
                 ********************************
                 *   BATCH FLOTATION STUDIES    *
                 *   ON GREGG RIVER RESOURCES   *
                 *          FINE COAL           *
                 ********************************


IDENTIFICATION: BLOCK#  4     TEST# 17     DATE:   FEB. 18,1983          TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
-----------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT.     -1       0.2        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS      1       8.0        %
RPM           1       1250.0
PH           -1       7.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 108.0     RESERVOIR WATER ADDED(G)=1996.4
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
--------------------------------------------------------------------------
 0.50      38.45       7.27     19.05      38.45        7.27     19.05
 1.00      22.08       7.61     21.54      60.53        7.40     19.89
 2.00      17.02       8.97     24.56      77.54        7.74     20.75
 4.00       6.64      10.06      8.95      84.18        7.92     18.80
 8.00       1.57      21.36      2.09      85.74        8.17     16.40
--------------------------------------------------------------------------
TAILINGS   14.26      33.14      1.08      N/A        N/A        N/A
--------------------------------------------------------------------------
FEED      100.00      11.69      5.44     100.00      11.69      N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.66
                                           ------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      40.37     23.91       9.39
 1.00      63.47     38.28      14.02
 2.00      81.01     51.33      17.02
 4.00      87.77     57.04      20.90
 8.00      89.17     59.90      25.13
----------------------------------------
```

```
                 ********************************
                 *   BATCH FLOTATION STUDIES    *
                 *   ON GREGG RIVER RESOURCES   *
                 *          FINE COAL           *
                 ********************************


IDENTIFICATION: BLOCK#  3     TEST# 18     DATE:   JAN. 31, 1983         TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
-----------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT.     -1       0.2        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS      1       8.0        %
RPM          -1       950.0
PH           -1       7.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 76.0      RESERVOIR WATER ADDED(G)=1748.0
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
--------------------------------------------------------------------------
 0.50      39.28       6.90     22.15      39.28        6.90     22.15
 1.00      22.25       7.41     24.05      61.53        7.08     22.80
 2.00      15.74       9.11     20.34      77.27        7.50     22.28
 4.00       7.87      11.27     11.22      85.15        7.85     20.40
 8.00       2.19      18.50      3.22      87.34        8.11     17.99
--------------------------------------------------------------------------
TAILINGS   12.66      37.04      1.03      N/A        N/A        N/A
--------------------------------------------------------------------------
FEED      100.00      11.80      5.82     100.00      11.80      N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.82
                                           ------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      41.47     22.98       8.54
 1.00      64.82     36.95      12.89
 2.00      81.04     49.11      16.70
 4.00      88.96     56.63      20.65
 8.00      90.99     60.06      24.63
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  3     TEST# 19     DATE:   JAN. 11,1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
----------------------------------------
AIR           -1        3.0        L/MIN.
COLLECT.       1        3.0        L/TONNE
FROTHER       -1        0.15       L/TONNE
CONDIT.       -1        1.0        MINUTES
% SOLIDS       1        9.0        %
RPM           -1        950.0
PH             1        8.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  72.0     RESERVOIR WATER ADDED(G)=2187.7
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %       CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                      % SOLIDS    ASH         SOLIDS
-------------------------------------------------------------------------
 0.50       28.74      7.33     21.98       28.74        7.33       21.98
 1.00       29.46      7.81     23.62       58.19        7.58       22.78
 2.00       14.82      9.76     19.89       73.02        8.02       22.12
 4.00        5.34     14.47      6.53       78.36        8.46       19.03
 8.00        4.55     15.01      4.05       82.91        8.82       15.82
-------------------------------------------------------------------------
TAILINGS    17.09     26.00      1.32       N/A         N/A         N/A
-------------------------------------------------------------------------
FEED       100.00     11.78      5.49      100.00       11.78       N/A
-------------------------------------------------------------------------
                                            MEASURED: 11.80
                                            ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS   ASH         WATER
TIME
----------------------------------------
 0.50       30.18      17.89        5.92
 1.00       60.97      37.43       11.46
 2.00       76.13      49.71       14.92
 4.00       81.31      56.27       19.36
 8.00       85.69      62.05       25.61
----------------------------------------




                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  4     TEST# 20     DATE   FEB. 15, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
----------------------------------------
AIR            1        7.0        L/MIN.
COLLECT.       1        3.0        L/TONNE
FROTHER       -1        0.15       L/TONNE
CONDIT        -1        1.0        MINUTES
% SOLIDS       1        9.0        %
RPM            1        1250.0
PH             1        8.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 108.0     RESERVOIR WATER ADDED(G)=1383.7
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %       CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                      % SOLIDS    ASH         SOLIDS
-------------------------------------------------------------------------
 0.50       56.99      8.92     19.66       56.99        8.92       19.66
 1.00       19.61     10.22     22.30       76.60        9.25       20.29
 2.00       13.56     11.55     19.18       90.16        9.60       20.11
 4.00        3.81     11.77      8.22       93.98        9.68       19.00
 8.00        1.28     18.41      2.64       95.26        9.80       17.64
-------------------------------------------------------------------------
TAILINGS     4.74     53.77      0.41       N/A         N/A         N/A
-------------------------------------------------------------------------
FEED       100.00     11.84      5.90      100.00       11.84       N/A
-------------------------------------------------------------------------
                                            MEASURED: 11.79
                                            ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS   ASH         WATER
TIME
----------------------------------------
 0.50       58.88      42.94       14.59
 1.00       78.85      59.87       18.88
 2.00       92.45      73.10       22.47
 4.00       96.27      76.89       25.14
 8.00       97.46      78.89       27.90
----------------------------------------
```

```
                    *********************************
                    *   BATCH FLOTATION STUDIES     *
                    *   ON GREGG RIVER RESOURCES    *
                    *           FINE COAL           *
                    *********************************

IDENTIFICATION  BLOCK#  3     TEST# 21     DATE:   JAN. 12, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED       ACTUAL.   UNITS
           LEVEL       LEVEL
----------------------------------------
AIR          -1        3.0       L/MIN.
COLLECT.     -1        0.2       L/TONNE
FROTHER       1        0.35      L/TONNE
CONDIT       -1        1.0       MINUTES
% SOLIDS      1        9.0       %
RPM          -1        950.0
PH            1        8.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0      RESERVOIR WATER ADDED(G)=1146.6
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                     % SOLIDS   ASH         SOLIDS
------------------------------------------------------------------------------
 0.50      17.39       6.60     22.10      17.39       6.60       22.10
 1.00      23.92       6.71     23.78      41.31       6.66       23.04
 2.00      23.55       7.55     21.88      64.86       6.98       22.53
 4.00      14.33      10.03     16.00      79.19       7.53       20.98
 8.00       7.04      12.08      8.20      86.23       7.91       17.56
------------------------------------------------------------------------------
TAILINGS   13.77      35.14      1.27      N/A        N/A         N/A
------------------------------------------------------------------------------
FEED      100.00      11.75      6.35     100.00      11.75       N/A
------------------------------------------------------------------------------
                                           MEASURED: 11.85
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      18.40       9.77      4.16
 1.00      43.69      23.42      9.36
 2.00      68.37      38.54     15.14
 4.00      82.98      50.78     20.24
 8.00      89.98      58.01     27.46
----------------------------------------
```

```
                    *********************************
                    *   BATCH FLOTATION STUDIES     *
                    *   ON GREGG RIVER RESOURCES    *
                    *           FINE COAL           *
                    *********************************

IDENTIFICATION  BLOCK#  4     TEST# 22     DATE:   FEB. 15, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED       ACTUAL    UNITS
           LEVEL       LEVEL
----------------------------------------
AIR           1        7.0       L/MIN.
COLLECT      -1        0.2       L/TONNE
FROTHER       1        0.35      L/TONNE
CONDIT       -1        1.0       MINUTES
% SOLIDS      1        9.0       %
RPM           1        1250.0
PH            1        8.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 106.0      RESERVOIR WATER ADDED(G)=1663.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                     % SOLIDS   ASH         SOLIDS
------------------------------------------------------------------------------
 0.50      64.45       8.72     18.40      64.45       8.72       18.40
 1.00      13.18      10.28     18.14      77.63       8.98       18.36
 2.00      12.05      11.31     13.66      89.68       9.30       17.55
 4.00       4.73      15.44      6.27      94.40       9.60       16.10
 8.00       1.22      19.91      2.22      95.62       9.74       14.92
------------------------------------------------------------------------------
TAILINGS    4.38      54.11      0.35      N/A        N/A         N/A
------------------------------------------------------------------------------
FEED      100.00      11.73      6.31     100.00      11.73       N/A
------------------------------------------------------------------------------
                                           MEASURED: 11.79
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      66.65      47.89     16.01
 1.00      80.04      59.44     19.34
 2.00      92.15      71.06     23.61
 4.00      96.68      77.28     27.57
 8.00      97.78      79.34     30.56
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  3     TEST# 23     DATE:   FEB. 1, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
-------------------------------------------
AIR          -1      3.0        L/MIN.
COLLECT.      1      3.0        L/TONNE
FROTHER       1      0.35       L/TONNE
CONDIT.      -1      1.0        MINUTES
% SOLIDS      1      8.0        %
RPM           1      1250.0
PH           -1      7.8
-------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  96.0     RESERVOIR WATER ADDED(G)=2355.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-------------------------------------------------------------------------
 0.50      41.28      9.42      18.64      41.28       9.42      18.64
 1.00      19.76      9.50      24.33      61.04       9.45      20.17
 2.00      17.79      9.57      20.24      78.83       9.47      20.18
 4.00       6.44     12.56       6.67      85.27       9.71      17.51
 8.00       3.39     15.10       3.64      88.66       9.91      16.28
-------------------------------------------------------------------------
TAILINGS   11.34     25.85       0.87      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.80       5.29     100.00      11.80      N/A
-------------------------------------------------------------------------
                                           MEASURED: 11.87
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-------------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
-------------------------------------------
 0.50      42.39     32.97      10.06
 1.00      62.66     48.88      13.49
 2.00      80.90     63.30      17.40
 4.00      87.29     70.17      22.44
 8.00      90.55     74.51      27.44
-------------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  3     TEST# 24     DATE:   FEB. 1, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
-------------------------------------------
AIR           1      7.0        L/MIN.
COLLECT.      1      3.0        L/TONNE
FROTHER       1      0.35       L/TONNE
CONDIT.      -1      1.0        MINUTES
% SOLIDS      1      8.0        %
RPM          -1      850.0
PH           -1      7.8
-------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  62.0     RESERVOIR WATER ADDED(G)=2031.0
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-------------------------------------------------------------------------
 0.50      47.69      8.81      20.05      47.69       8.81      20.05
 1.00      22.27      9.00      22.07      69.96       8.87      20.65
 2.00      14.17     11.68      15.37      84.14       9.34      19.52
 4.00       7.83     13.71       8.02      91.96       9.72      17.40
 8.00       3.81     13.41       5.81      95.77       9.88      16.88
-------------------------------------------------------------------------
TAILINGS    4.23     50.21       0.33      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.71       5.42     100.00      11.71      N/A
-------------------------------------------------------------------------
                                           MEASURED: 11.84
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-------------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
-------------------------------------------
 0.50      49.25     35.80      10.89
 1.00      72.21     53.02      15.39
 2.00      86.39     67.16      19.86
 4.00      94.04     76.32      25.00
 8.00      97.77     80.58      27.00
-------------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES.   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION  BLOCK#  4     TEST# 25     DATE:   FEB. 14, 1983          TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
-------------------------------------------
AIR           -1        3.0        L/MIN.
COLLECT       -1        0.2        L/TONNE
FROTHER       -1        0.15       L/TONNE
CONDIT.        1        5.0        MINUTES
% SOLIDS       1        9.0        %
RPM           -1        950.0
PH             1        8.8
-------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 800.6
-------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM        CUM        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-------------------------------------------------------------------------
 0.50      25.59      6.49      22.59      25.59      6.49       22.59
 1.00      28.00      6.88      24.85      53.59      6.69       23.71
 2.00      18.47      7.65      25.44      72.06      6.94       24.13
 4.00      12.98      9.41      22.02      85.04      7.32       23.79
 8.00       3.09     12.11       8.59      88.14      7.45       22.39
-------------------------------------------------------------------------
TAILINGS   11.86     40.47       1.18      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.58       7.04     100.00     11.58       N/A
-------------------------------------------------------------------------
                                           MEASURED: 11.78
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-------------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
-------------------------------------------
 0.50      27.06     14.35       6.65
 1.00      56.55     30.89      13.06
 2.00      75.64     43.19      17.16
 4.00      89.14     53.75      20.65
 8.00      92.22     56.88      23.14
-------------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  4     TEST# 26     DATE:   FEB. 14, 1983          TYPE:   SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
-------------------------------------------
AIR            1        7.0        L/MIN.
COLLECT       -1        0.2        L/TONNE
FROTHER       -1        0.15       L/TONNE
CONDIT         1        5.0        MINUTES
% SOLIDS       1        9.0        %
RPM            1        1250.0
PH             1        8.8
-------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 100.0     RESERVOIR WATER ADDED(G)=1810.2
-------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM        CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-------------------------------------------------------------------------
 0.50      60.11      7.52      21.11      60.11      7.52       21.11
 1.00      16.44      8.91      21.93      76.55      7.82       21.28
 2.00       9.46     11.58      13.55      86.01      8.23       20.03
 4.00       4.43     13.74       5.05      90.44      8.50       17.49
 8.00       1.38     23.38       1.90      91.82      8.72       15.87
-------------------------------------------------------------------------
TAILINGS    8.18     45.78       0.84      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.78       5.35     100.00     11.78       N/A
-------------------------------------------------------------------------
                                           MEASURED: 11.74
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-------------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
-------------------------------------------
 0.50      63.02     38.35      12.70
 1.00      80.00     50.77      16.01
 2.00      89.48     60.04      19.42
 4.00      93.81     65.20      24.12
 8.00      95.01     67.94      28.14
-------------------------------------------
```

```
*******************************
*  BATCH FLOTATION STUDIES    *
*  ON GREGG RIVER RESOURCES   *
*         FINE COAL           *
*******************************

IDENTIFICATION: BLOCK#  4     TEST# 27     DATE:   FEB. 18, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT.      1       3.0        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS      1       9.0        %
RPM           1       1250.0
PH           -1       7.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 100.0     RESERVOIR WATER ADDED(G)=2752.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM.
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-----------------------------------------------------------------------
 0.50       38.54      8.99      17.29      38.54      8.99      17.29
 1.00       21.89      9.19      23.37      60.43      9.06      19.09
 2.00       22.01      9.73      23.54      82.43      9.24      20.10
 4.00        9.69     11.64       6.05      92.13      9.49      16.15
 8.00        1.09     21.02       1.39      93.21      9.63      14.37
-----------------------------------------------------------------------
TAILINGS     6.79     35.29       0.47     N/A        N/A        N/A
-----------------------------------------------------------------------
FEED       100.00     11.48       4.76    100.00      11.48      N/A
-----------------------------------------------------------------------
                                          MEASURED: 11.59
                                          ------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       39.62     30.18      9.21
 1.00       62.08     47.72     12.80
 2.00       84.52     66.36     16.37
 4.00       94.19     75.18     23.90
 8.00       95.16     78.17     27.76
----------------------------------------
```

```
*******************************
*  BATCH FLOTATION STUDIES    *
*  ON GREGG RIVER RESOURCES   *
*         FINE COAL           *
*******************************

IDENTIFICATION: BLOCK#  3     TEST# 26     DATE:   FEB. 2, 1983           TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT       1       3.0        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT        1       5.0        MINUTES
% SOLIDS      1       9.0        %
RPM          -1       950.0
PH           -1       7.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  62.0     RESERVOIR WATER ADDED(G)=1591.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM.
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-----------------------------------------------------------------------
 0.50       41.04      8.51      20.12      41.04      8.51      20.12
 1.00       23.24      8.96      20.44      64.28      8.67      20.23
 2.00       19.35     10.16      22.65      83.63      9.01      20.74
 4.00        8.10     10.81      17.43      91.73      9.17      20.40
 8.00        2.83     14.45       9.11      94.57      9.33      19.67
-----------------------------------------------------------------------
TAILINGS     5.43     51.21       0.45     N/A        N/A        N/A
-----------------------------------------------------------------------
FEED       100.00     11.69       5.93    100.00      11.69      N/A
-----------------------------------------------------------------------
                                          MEASURED: 11.77
                                          ------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       42.52     29.88     10.28
 1.00       66.48     47.69     15.98
 2.00       86.16     64.50     20.15
 4.00       94.34     72.00     22.57
 8.00       97.09     75.50     24.35
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  4     TEST# 29     DATE:   FEB. 17,1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          -1       3.0        L/MIN
COLLECT.     -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT        1       5.0        MINUTES
% SOLIDS      1       9.0        %
RPM           1       1250.0
PH           -1       7.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 110.0     RESERVOIR WATER ADDED(G)=2184.6
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
----------------------------------------------------------------------
 0.50      43.67      8.05      18.45      43.67       8.05      18.45
 1.00      20.40      9.04      18.23      64.07       8.37      18.38
 2.00      16.01      9.42      15.34      80.08       8.58      17.88
 4.00      10.00      9.95      10.10      90.08       8.73      16.32
 8.00       2.81     16.14       3.02      92.89       8.95      14.35
----------------------------------------------------------------------
TAILINGS    7.01     44.33       0.52      N/A        N/A        N/A
----------------------------------------------------------------------
FEED      100.00     11.61       5.01     100.00      11.61      N/A
----------------------------------------------------------------------
                                          MEASURED: 11.77
                                          ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      45.42     30.30      10.17
 1.00      66.42     46.20      14.98
 2.00      82.82     59.20      19.65
 4.00      93.01     67.77      24.34
 8.00      95.76     71.81      29.25
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     TEST# 30     DATE:   FEB. 3, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR           1       7.0        L/MIN
COLLECT.     -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS      1       9.0        %
PPM          -1       850.0
PH            1       8.8
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  82.0     RESERVOIR WATER ADDED(G)=2485.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
----------------------------------------------------------------------
 0.50      51.56      7.90      17.88      51.56       7.90      17.88
 1.00      23.82      8.89      20.93      75.38       8.22      18.60
 2.00       8.35     14.46      11.75      83.73       8.84      17.58
 4.00       9.32     14.56       7.48      93.05       9.41      15.48
 8.00       1.88     26.82       1.45      94.93       9.76      12.99
----------------------------------------------------------------------
TAILINGS    5.07     47.88       0.36      N/A        N/A        N/A
----------------------------------------------------------------------
FEED      100.00     11.72       4.65     100.00      11.72      N/A
----------------------------------------------------------------------
                                          MEASURED: 11.76
                                          ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      53.79     34.77      11.71
 1.00      78.37     52.84      16.10
 2.00      86.46     63.14      19.18
 4.00      95.48     74.74      24.79
 8.00      97.04     79.05      31.02
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     TEST# 31     DATE:    JAN. 18, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
-----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT.      1       3.0        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS      1       9.0        %
RPM          -1       950.0
PH            1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  75.0     RESERVOIR WATER ADDED(G)=1371.9
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %       WT. %      CUM.        CUM.        CUM
INCREMENT SOLIDS %  ASH         SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
-----------------------------------------------------------------------------
 0.50      33.13       7.61      23.10      33.13        7.61      23.10
 1.00      23.28       8.07      22.62      56.41        7.80      22.90
 2.00      21.62       9.24      19.23      78.04        8.20      21.75
 4.00       6.47      11.51       9.92      84.50        8.45      19.93
 8.00       2.83      17.14       3.61      87.34        8.73      17.38
-----------------------------------------------------------------------------
TAILINGS  12.66      31.92       1.10      N/A          N/A         N/A
-----------------------------------------------------------------------------
FEED     100.00      11.74       6.05     100.00       11.74        N/A
-----------------------------------------------------------------------------
                                           MEASURED: 11.81
                                           ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
 0.50       34.66     21.46       7.11
 1.00       58.93     37.46      12.24
 2.00       81.17     54.50      16.09
 4.00       87.65     60.84      21.88
 8.00       90.31     64.97      26.76
-----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  4     TEST# 32     DATE:    FEB. 10, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
-----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT.      1       3.0        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT.       1       5.0        MINUTES
% SOLIDS      1       9.0        %
RPM           1       1250.0
PH            1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 110.0     RESERVOIR WATER ADDED(G)=2366.2
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %       WT. %      CUM.        CUM.        CUM
INCREMENT SOLIDS %  ASH         SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
-----------------------------------------------------------------------------
 0.50      52.68       9.80      17.57      52.68        9.80      17.57
 1.00      18.40      10.03      22.96      71.07        9.86      18.71
 2.00      20.25      10.85      18.65      91.33       10.08      18.69
 4.00       5.13      13.18       6.39      96.46       10.25      16.98
 8.00       0.58      36.75       0.52      97.04       10.41      14.24
-----------------------------------------------------------------------------
TAILINGS   2.96      57.27       0.22      N/A          N/A         N/A
-----------------------------------------------------------------------------
FEED     100.00      11.82       4.93     100.00       11.82        N/A
-----------------------------------------------------------------------------
                                           MEASURED: 11.85
                                           ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
 0.50       53.88     43.59      12.81
 1.00       72.65     58.31      16.01
 2.00       93.13     77.91      20.59
 4.00       96.18     83.63      24.48
 8.00       98.60     85.43      30.28
-----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     CNTR#  1     DATE:   JAN. 20,1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL      UNITS
            LEVEL       LEVEL
----------------------------------------------
AIR           0         5.0         L/MIN.
COLLECT       0         1.6         L/TONNE
FROTHER       0         0.25        L/TONNE
CONDIT.       0         3.0         MINUTES
% SOLIDS      0         6.0         %
RPM           0         1100.0
PH            0         8.3
----------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  86.0      RESERVOIR WATER ADDED(G)=1908.6
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT       RECOVERED WT. %       WT. %       CUM.        CUM.        CUM
INCREMENT   SOLIDS %  ASH         SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                        % SOLIDS    ASH         SOLIDS
-------------------------------------------------------------------------------
 0.50        38.72      7.93      20.84        38.72       7.93       20.84
 1.00        26.34      8.20      25.11        65.06       8.04       22.38
 2.00        15.94     10.54      16.01        81.00       8.53       21.36
 4.00         8.50     12.23       6.38        89.50       8.88       17.47
 8.00         2.71     18.63       1.73        92.21       9.17       13.78
-------------------------------------------------------------------------------
TAILINGS      7.79     40.18       0.41        N/A         N/A         N/A
-------------------------------------------------------------------------------
FEED        100.00     11.62       3.88       100.00      11.62        N/A
-------------------------------------------------------------------------------
                                              MEASURED: 11.66
                                              -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------------
FLOAT       ORGANICS  ASH         WATER
TIME
----------------------------------------------
 0.50        40.23     26.42        5.95
 1.00        67.70     45.01        9.13
 2.00        83.83     59.47       12.06
 4.00        92.27     66.42       17.11
 8.00        94.78     72.75       23.33
----------------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     CNTR#  2     DATE:   JAN. 20,1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL      UNITS
            LEVEL       LEVEL
----------------------------------------------
AIR           0         5.0         L/MIN.
COLLECT       0         1.6         L/TONNE
FROTHER       0         0.25        L/TONNE
CONDIT.       0         3.0         MINUTES
% SOLIDS      0         6.0         %
RPM           0         1100.0
PH            0         8.3
----------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  79.0      RESERVOIR WATER ADDED(G)=4514.0
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT       RECOVERED WT. %       WT. %       CUM.        CUM.        CUM
INCREMENT   SOLIDS %  ASH         SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                        % SOLIDS    ASH         SOLIDS
-------------------------------------------------------------------------------
 0.50        39.53      7.93      20.20        39.53       7.93       20.20
 1.00        26.20      8.28      24.15        65.72       8.07       21.61
 2.00        15.60     10.38      13.53        81.32       8.51       19.39
 4.00         7.06     11.28       9.18        88.38       8.73       17.81
 8.00         1.33     13.54       0.36        89.72       8.80       10.31
-------------------------------------------------------------------------------
TAILINGS     10.28     36.82       0.37        N/A         N/A         N/A
-------------------------------------------------------------------------------
FEED        100.00     11.58       2.76       100.00      11.58        N/A
-------------------------------------------------------------------------------
                                              MEASURED: 11.50
                                              -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------------
FLOAT       ORGANICS  ASH         WATER
TIME
----------------------------------------------
 0.50        41.18     27.07        4.43
 1.00        68.33     45.80        6.76
 2.00        84.15     59.78        9.59
 4.00        91.23     66.64       11.57
 8.00        92.53     68.20       22.14
----------------------------------------------
```

```
                   ********************************
                   *   BATCH FLOTATION STUDIES    *
                   *   ON GREGG RIVER RESOURCES   *
                   *          FINE COAL           *
                   ********************************

IDENTIFICATION: BLOCK#  3     CNTR#  3     DATE:   JAN. 21, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED,     ACTUAL     UNITS
            LEVEL      LEVEL
--------------------------------------------
AIR           0        5.0        L/MIN.
COLLECT.      0        1.5        L/TONNE
FROTHER       0        0.25       L/TONNE
CONDIT.       0        3.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
--------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  86.0      RESERVOIR WATER ADDED(G)=2161.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.         CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %        WT. %
(MIN.)                                     % SOLIDS    ASH          SOLIDS
--------------------------------------------------------------------------
 0.50       37.73      7.99     20.76      37.73        7.99        20.76
 1.00       26.17      8.29     25.34      63.89        8.11        22.42
 2.00       17.19     10.22     18.10      81.09        8.56        21.34
 4.00        5.85     13.45      5.36      86.93        8.89        17.77
 8.00        2.90     20.31      1.49      89.84        9.26        13.14
--------------------------------------------------------------------------
TAILINGS   10.16      41.84      0.53      N/A          N/A         N/A
--------------------------------------------------------------------------
FEED      100.00      12.13      3.83     100.00        12.13       N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.89
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       39.50     24.86       5.74
 1.00       66.61     42.74       8.81
 2.00       84.36     57.23      11.91
 4.00       90.14     63.71      16.03
 8.00       92.77     66.58      23.66
----------------------------------------
```

```
                   ********************************
                   *   BATCH FLOTATION STUDIES    *
                   *   ON GREGG RIVER RESOURCES   *
                   *          FINE COAL           *
                   ********************************

IDENTIFICATION: BLOCK#  3     CNTR#  4     DATE:   JAN 21, 1983           TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
--------------------------------------------
AIR           0        5.0        L/MIN.
COLLECT       0        1.5        L/TONNE
FROTHER       0        0.25       L/TONNE
CONDIT.       0        3.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
--------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  82.0      RESERVOIR WATER ADDED(G)=1775.0
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.         CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %        WT. %
(MIN.)                                     % SOLIDS    ASH          SOLIDS
--------------------------------------------------------------------------
 0.50       35.25      7.98     21.31      35.25        7.98        21.31
 1.00       24.68      8.32     26.22      59.93        8.12        23.09
 2.00       18.14      9.28     25.12      78.07        8.39        23.53
 4.00       11.80     11.70      8.99      89.87        8.83        19.41
 8.00        2.42     18.65      1.92      92.29        9.08        15.67
--------------------------------------------------------------------------
TAILINGS    7.71      42.16      0.41      N/A          N/A         N/A
--------------------------------------------------------------------------
FEED      100.00      11.57      4.04     100.00        11.57       N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.71
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       36.72     24.11       5.48
 1.00       62.34     41.71       8.41
 2.00       80.97     56.13      10.68
 4.00       92.77     67.97      15.72
 8.00       94.99     71.63      20.91
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  3     CNTR#  5     DATE:   JAN. 23, 1983          TYPE:   SCREENING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
-----------------------------------------
AIR          0        5.0        L/MIN.
COLLECT.     0        1.6        L/TONNE
FROTHER      0        0.25       L/TONNE
CONDIT.      0        3.0        MINUTES
% SOLIDS     0        8.0        %
RPM          0        1100.0
PH           0        8.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  80.0     RESERVOIR WATER ADDED(G)=1709.2
-------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %      WT. %
(MIN.)                                     % SOLIDS    ASH        SOLIDS
--------------------------------------------------------------------------
 0.50      38.16       7.96     21.02      38.16        7.96      21.02
 1.00      22.54       8.31     28.34      60.70        8.09      22.73
 2.00      21.35       9.33     22.72      82.05        8.41      22.73
 4.00       8.48      11.50     10.00      90.53        8.70      20.31
 8.00       1.95      26.23      0.99      92.48        9.07      14.39
--------------------------------------------------------------------------
TAILINGS    7.52      42.56      0.40      N/A         N/A        N/A
--------------------------------------------------------------------------
FEED      100.00      11.83      3.97     100.00       11.83      N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.87
                                           ----------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS   ASH        WATER
TIME
----------------------------------------
 0.50       38.74      26.13       5.93
 1.00       63.13      42.24       8.54
 2.00       85.04      59.36      11.55
 4.00       93.53      67.75      14.70
 8.00       95.16      72.14      22.77
----------------------------------------
```

The Size Fraction Studies On The Screening Tests

```
                ********************************
                *    SIZE FRACTION  STUDIES    *
                *  ON GREGG RIVER RESOURCES    *
                *          FINE COAL           *
                ********************************


IDENTIFICATION:   TEST#   1          DATE: 1   MONTH  4   YEAR 1983
...............

SIZE FREQUENCY PER MESH AND ASH DATA:
.....................................
            +200 MESH           -200/+325          -325 MESH
    TIME    WT%      % ASH     WT%      % ASH     WT%      % ASH
.....................................................................
    30 SEC   11.13     4.23     34.76     4.45     35.15     5.51
    1  MIN    5.89     4.26     12.91     4.32     14.56     5.46
    2  MIN    3.32     4.15     11.92     4.29      4.80     5.87
    4  MIN    2.04     4.84      3.48     5.49      4.73     5.68
    8  MIN    2.87     5.32      3.79     9.57      3.93     9.84
    TAIL     74.75    13.15     33.15    23.97     35.83    24.57
.....................................................................

SIZE FREQUENCY PER INCREMENT:
.............................
            +200 MESH  -200/+325  -325 MESH
...........................................
    30 SEC   15.11        23.19      61.70
    1  MIN   19.28        20.78      59.94
    2  MIN   21.84        38.48      39.68
    4  MIN   21.07        17.61      61.32
    8  MIN   29.65        19.24      51.10
    TAIL     54.93        11.97      33.10
...........................................
    FEED     36.38        17.88      45.74
...........................................

RECOVERY DATA:
..............
            +200 MESH              -200/+325            -325 MESH
    TIME     %ASH      %ORG,      %ASH      %ORG      %ASH      %ORG      WATER
.................................................................................
    30 SEC    4.26     11.99     13.92     37.37     15.89     38.05      2.29
    1  MIN    6.53     16.32     18.94     51.26     22.24     54.78      3.80
    2  MIN    7.78     21.90     23.54     64.10     24.49     59.95      5.04
    4  MIN    8.69     24.09     25.26     67.79     26.63     65.05      7.05
    8  MIN   11.11     27.01     26.52     71.65     29.72     69.10     11.56
.................................................................................

BACK CALCULATION OF FEED ASSAY:
...............................
CALCULATED %ASH IN FEED: 11.74
MEASURED % ASH IN FEED:  11.76
...............................


                ********************************
                *    SIZE FRACTION  STUDIES    *
                *  ON GREGG RIVER RESOURCES    *
                *          FINE COAL           *
                ********************************


IDENTIFICATION:   TEST#   2          DATE: 3   MONTH: 4   YEAR 1983
...............

SIZE FREQUENCY PER MESH AND ASH DATA:
.....................................
            +200 MESH           -200/+325          -325 MESH
    TIME    WT%      % ASH     WT%      % ASH     WT%      % ASH
.....................................................................
    30 SEC   36.76     4.62     38.15     5.30     54.29     6.40
    1  MIN    9.03     5.50      8.87     6.55     14.71     7.32
    2  MIN    7.04     5.96      7.40     7.23     10.15     8.12
    4  MIN    7.09     7.07     10.54     8.38      9.63    10.10
    8  MIN    3.81     9.76      6.26    11.63      4.64    13.33
    TAIL     36.25    19.38     28.77    28.92      6.57    40.38
.....................................................................

SIZE FREQUENCY PER INCREMENT:
.............................
            +200 MESH  -200/+325  -325 MESH
...........................................
    30 SEC   29.76        15.16      55.07
    1  MIN   28.38        13.68      57.94
    2  MIN   30.07        15.52      54.41
    4  MIN   29.14        21.27      49.59
    8  MIN   29.94        24.27      45.79
    TAIL     61.84        24.11      14.05
...........................................
    FEED     36.43        17.90      45.67
...........................................

RECOVERY DATA:
..............
            +200 MESH              -200/+325            -325 MESH
    TIME     %ASH      %ORG       %ASH      %ORG      %ASH      %ORG      WATER
.................................................................................
    30 SEC   16.16     39.20     15.46     41.55     36.12     56.22      3.36
    1  MIN   20.89     48.74     19.91     51.09     47.31     71.30      4.82
    2  MIN   24.68     56.13     24.00     58.98     55.88     81.64      7.59
    4  MIN   29.65     63.50     30.75     70.09     65.99     91.21     12.12
    8  MIN   33.18     67.34     36.34     76.47     72.42     95.67     17.84
.................................................................................

BACK CALCULATION OF FEED ASSAY:
...............................
CALCULATED %ASH IN FEED: 10.56
MEASURED % ASH IN FEED:  11.93
...............................
```

```
*******************************
*    SIZE FRACTION  STUDIES   *
*  ON GREGG RIVER RESOURCES   *
*          FINE COAL          *
*******************************


IDENTIFICATION:    TEST#   3           DATE: 5   MONTH: 4   YEAR:1983
---------------


SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
             +200 MESH            -200/+325          -325 MESH
    TIME     WT%       % ASH     WT%       % ASH     WT%       % ASH
----------------------------------------------------------------------
   30 SEC    33.01      6.55     43.99      6.72     39.44      5.76
   1  MIN    10.07      6.05      8.49      6.42     11.12      6.76
   2  MIN     1.13      9.21      1.60      9.02      0.95      8.38
   4  MIN     3.29      9.93      4.33     10.63      4.94     11.07
   8  MIN     2.10      7.93      2.91      8.69      3.84      8.53
   TAIL      50.39     17.66     38.69     18.73     39.71     20.67
----------------------------------------------------------------------


SIZE FREQUENCY PER INCREMENT:
-----------------------------
             +200 MESH  -200/+325  -325 MESH
--------------------------------------------
   30 SEC    31.95          19.66      48.38
   1  MIN    35.86          13.95      50.19
   2  MIN    36.75          23.93      39.32
   4  MIN    28.47          17.31      54.21
   8  MIN    25.32          16.14      58.54
   TAIL      42.50          15.06      42.44
--------------------------------------------
   FEED      36.65          16.92      46.44
--------------------------------------------


RECOVERY DATA:
--------------
             +200 MESH            -200/+325          -325 MESH
    TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
--------------------------------------------------------------------------------
   30 SEC    17.61     35.16     25.46     46.42     21.26     42.06      1.83
   1  MIN    22.56     45.95     30.16     55.41     27.22     53.92      3.24
   2  MIN    23.43     47.12     31.42     57.05     27.86     54.92      5.58
   4  MIN    26.09     50.60     35.39     61.43     32.20     59.95     10.64
   8  MIN    27.45     52.70     37.57     64.43     34.80     63.97     13.74
--------------------------------------------------------------------------------


BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.30
MEASURED % ASH IN FEED:  11.91
-------------------------------
```

```
*******************************
*    SIZE FRACTION  STUDIES   *
*  ON GREGG RIVER RESOURCES   *
*          FINE COAL          *
*******************************


IDENTIFICATION     TEST#   4           DATE: 6   MONTH: 4   YEAR:1983
---------------


SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
             +200 MESH            -200/+325          -325 MESH
    TIME     WT%       % ASH     WT%       % ASH     WT%       % ASH
----------------------------------------------------------------------
   30 SEC    35.99      6.50     42.86      7.19     42.31      7.35
   1  MIN     8.75      6.98      9.22      7.16     12.31      7.79
   2  MIN     6.70      8.13      8.01      8.15      3.62      9.85
   4  MIN    12.31      8.76     11.28      9.25     14.79      9.71
   8  MIN     5.16     10.91      4.34     10.40      2.19     13.58
   TAIL      31.09     18.38     24.30     22.40     24.78     25.00
----------------------------------------------------------------------


SIZE FREQUENCY PER INCREMENT:
-----------------------------
             +200 MESH  -200/+325  -325 MESH
--------------------------------------------
   30 SEC    31.25          21.34      47.40
   1  MIN    29.25          17.67      53.09
   2  MIN    41.96          28.78      29.26
   4  MIN    32.52          17.07      50.41
   8  MIN    49.25          23.77      26.98
   TAIL      40.39          18.09      41.52
--------------------------------------------
   FEED      34.92          20.02      45.05
--------------------------------------------


RECOVERY DATA:
--------------
             +200 MESH            -200/+325          -325 MESH
    TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
--------------------------------------------------------------------------------
   30 SEC    21.56     37.75     27.21     44.86     25.18     44.73      2.87
   1  MIN    27.18     46.88     33.03     54.51     32.95     57.68      4.04
   2  MIN    32.20     53.78     38.79     62.81     35.83     61.40      5.46
   4  MIN    42.14     66.38     47.89     74.35     47.48     76.64      8.79
   8  MIN    47.33     71.53     51.98     78.74     48.86     78.80     13.66
--------------------------------------------------------------------------------


BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 11.62
MEASURED % ASH IN FEED:  11.76
-------------------------------
```

```
                   ********************************
                   *    SIZE FRACTION  STUDIES    *
                   *  ON GREGG RIVER RESOURCES    *
                   *          FINE COAL           *
                   ********************************


IDENTIFICATION:   TEST#   5          DATE:10   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
           +200 MESH            -200/+325            -325 MESH
   TIME     WT%      % ASH     WT%      % ASH     WT%     % ASH
---------------------------------------------------------------------
   30 SEC   48.45     6.46    49.35     6.60     35.92     8.03
   1  MIN   18.30     8.85    12.40     7.93     20.76     7.83
   2  MIN    2.33    10.88     3.86    10.83      3.15    11.02
   4  MIN    3.40    11.30     5.32    11.20      1.85    13.90
   8  MIN    3.53    10.56     3.34    11.27      4.95    11.08
   TAIL     25.95    21.01    25.74    22.63     33.38    26.25
---------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
------------------------------------------
   30 SEC   43.48         21.73     34.79
   1  MIN   36.38         13.59     50.03
   2  MIN   30.54         24.83     44.63
   4  MIN   42.49         32.59     24.92
   8  MIN   33.56         15.57     50.85
   TAIL     34.77         18.94     46.29
------------------------------------------
   FEED     38.90         19.10     42.00
------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH             -200/+325             -325 MESH
   TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
------------------------------------------------------------------------------
   30 SEC   28.18     50.81     28.44     52.05     20.07     38.59      3.00
   1  MIN   39.75     67.80   . 37.03     64.95     31.08     50.98      4.39
   2  MIN   42.07     70.13     40.67     68.83     33.49     64.28      6.70
   4  MIN   45.58     73.51     45.87     74.16     35.28     66.12      9.85
   8  MIN   49.14     77.04     49.15     77.51     39.10     71.28     12.87
------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.40
MEASURED % ASH IN FEED:  11.62
-------------------------------
```

```
                   ********************************
                   *    SIZE FRACTION  STUDIES    *
                   *  ON GREGG RIVER RESOURCES    *
                   *          FINE COAL           *
                   ********************************


IDENTIFICATION    TEST#   6          DATE:11   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
           +200 MESH            -200/+325            -325 MESH
   TIME     WT%      % ASH     WT%      % ASH     WT%     % ASH
---------------------------------------------------------------------
   30 SEC   61.38     7.46    62.43     8.76     55.44     8.03
   1  MIN   15.84     9.12     8.41     9.77     18.12     8.70
   2  MIN   13.89    12.15    18.82    12.18     14.23    11.77
   4  MIN    4.88    11.82     5.40    12.15      5.19    11.81
   8  MIN    3.20    14.15     2.63    14.80      0.72    13.88
   TAIL     10.71    26.32    12.31    28.64      8.29    40.55
---------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
------------------------------------------
   30 SEC   32.03         17.65     50.32
   1  MIN   34.01          9.69     56.30
   2  MIN   31.03         22.70     46.28
   4  MIN   31.79         18.87     49.23
   8  MIN   56.48         25.00     18.52
   TAIL     40.40         25.05     34.55
------------------------------------------
   FEED     33.38         18.02     48.60
------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH             -200/+325             -325 MESH
   TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
------------------------------------------------------------------------------
   30 SEC   35.40     53.32     37.43     54.53     40.62     57.26      4.14
   1  MIN   48.83     69.56     44.13     63.19     55.01     75.84      5.79
   2  MIN   64.42     83.24     62.78     82.03     70.30     89.94     10.16
   4  MIN   69.75     88.07     68.13     87.44     75.80     95.10     13.83
   8  MIN   73.95     91.15     71.29     89.99     76.70     95.80     19.82
------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 11.15
MEASURED % ASH IN FEED:  11.78
-------------------------------
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:   TEST#   7           DATE:11   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH              -200/+325             -325 MESH
   TIME      WT%       % ASH     WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
  30 SEC    49.46       8.00     40.43       8.38     43.26       8.11
  1  MIN     5.69       7.75      6.45       7.73      2.53       8.93
  2  MIN     4.52       9.55      4.89       9.70      4.17      10.34
  4  MIN     4.18       9.77      4.62       9.41      5.81       9.75
  8  MIN     8.83       9.26     10.65       9.34      7.98      10.85
  TAIL      27.30      18.12     32.96      21.55     36.24      22.51
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
---------------------------------------------
  30 SEC    42.25        16.39      41.36
  1  MIN    49.12        26.43      24.45
  2  MIN    39.25        20.18      40.56
  4  MIN    32.48        17.03      50.49
  8  MIN    38.70        22.15      39.15
  TAIL      32.69        18.73      48.58
---------------------------------------------
  FEED      38.55        18.30      43.15
---------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH             -200/+325            -325 MESH
   TIME     %ASH       %ORG       %ASH      %ORG       %ASH      %ORG       WATER
-----------------------------------------------------------------------------------
  30 SEC    35.98      51.15      26.29     42.52      25.53     46.09       4.23
  1  MIN    39.87      57.05      30.15     49.36      27.18     48.75       6.70
  2  MIN    43.80      61.64      33.84     54.43      30.32     53.10      10.40
  4  MIN    47.62      65.86      37.21     58.24      34.44     59.18      14.29
  8  MIN    55.05      74.86      44.82     70.32      40.62     67.44      19.34
-----------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED  12.53
MEASURED % ASH IN FEED:  11.65
-------------------------------
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:   TEST#   8           DATE:12   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH              -200/+325             -325 MESH
   TIME      WT%       % ASH     WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
  30 SEC    64.75       7.39     65.04       7.00     19.26      10.61
  1  MIN    14.68      10.44     12.27       9.85     47.28       9.68
  2  MIN     7.19      12.50      9.47      12.70     15.82      13.16
  4  MIN     6.71      12.25      8.98      13.30      8.50      14.64
  8  MIN     0.71      17.31      0.23      26.55      1.38      20.25
  TAIL       5.95      41.36      4.01      44.63      7.80      55.02
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
---------------------------------------------
  30 SEC    58.50        31.76       9.74
  1  MIN    30.73        13.88      55.39
  2  MIN    33.99        24.19      41.82
  4  MIN    41.11        29.75      29.15
  8  MIN    44.61         7.69      47.69
  TAIL      47.66        17.38      34.96
---------------------------------------------
  FEED      47.61        25.74      26.65
---------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH             -200/+325            -325 MESH
   TIME     %ASH       %ORG       %ASH      %ORG       %ASH      %ORG       WATER
-----------------------------------------------------------------------------------
  30 SEC    45.05      67.11      45.46     67.23      14.08     20.14       4.77
  1  MIN    59.47      81.82      57.63     79.50      45.85     70.08       7.12
  2  MIN    67.94      88.86      69.62     88.70      60.00     86.14      10.43
  4  MIN    75.68      95.44      81.53     97.35      68.52     94.64      13.82
  8  MIN    76.83      96.10      82.13     97.53      70.41     95.90      18.47
-----------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED  11.50
MEASURED % ASH IN FEED:  11.78
-------------------------------
```

```
                    ********************************
                    *   SIZE FRACTION  STUDIES     *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:   TEST# / 9          DATE:12   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH             -200/+325           -325 MESH
    TIME     WT%      % ASH     WT%      % ASH      WT%      % ASH
-------------------------------------------------------------------
   30 SEC    7.99     3.85     14.09     3.84      7.55      5.67
   1  MIN    4.35     5.01      6.59     5.00      9.18      6.19
   2  MIN    3.06     6.33      3.62     6.19      3.65      6.83
   4  MIN    2.22     5.90      2.88     5.50      5.11      6.36
   8  MIN    1.94     6.46      1.61     6.40      5.23      7.25
   TAIL     80.43    14.27     71.20    14.78     69.28     17.82
-------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   31.30        32.30       36.40
   1  MIN   22.36        19.76       57.88
   2  MIN   31.66        21.90       46.44
   4  MIN   21.80        16.54       61.65
   8  MIN   20.82        10.14       69.04
   TAIL     38.81        20.10       41.09
-------------------------------------------
   FEED     35.54        20.78       43.68
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH              -200/+325            -325 MESH
    TIME    %ASH       %ORG       %ASH      %ORG      %ASH      %ORG      WATER
-------------------------------------------------------------------------------
   30 SEC    2.47      6.77       4.55     15.38      2.88      8.32      1.12
   1  MIN    4.23     13.51       7.32     22.48      6.94     18.38      3.14
   2  MIN    5.78     16.78       9.21     26.34      8.70     22.35      6.19
   4  MIN    6.83     19.17      10.64     29.43     10.96     27.93      8.83
   8  MIN    7.84     21.24      11.41     31.14     13.60     33.60     11.65
-------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 13.17
MEASURED % ASH IN FEED:  11.74
-------------------------------
```

```
                    ********************************
                    *   SIZE FRACTION  STUDIES     *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION    TEST#  10          DATE:13   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH             -200/+325           -325 MESH
    TIME     WT%      % ASH     WT%      % ASH      WT%      % ASH
-------------------------------------------------------------------
   30 SEC    7.62     3.63      7.86     3.85     11.31      5.45
   1  MIN    6.28     3.52      8.92     3.73     12.45      5.11
   2  MIN    5.40     4.69      5.89     4.74      6.50      6.02
   4  MIN    5.51     7.99      7.68     7.67      8.62      8.71
   8  MIN    3.15     9.29      3.77     9.18      3.32      9.48
   TAIL     72.04    14.69     65.78    16.00     57.80     18.71
-------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   25.47        15.46       59.07
   1  MIN   20.31        16.77       62.92
   2  MIN   28.45        18.03       53.52
   4  MIN   23.49        19.04       57.47
   8  MIN   29.95        20.81       49.24
   TAIL     35.91        19.06       45.03
-------------------------------------------
   FEED     31.81        18.48       49.71
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH              -200/+325            -325 MESH
    TIME    %ASH       %ORG       %ASH      %ORG      %ASH      %ORG      WATER
-------------------------------------------------------------------------------
   30 SEC    2.29      6.35       2.64      8.72      4.56     12.36      1.39
   1  MIN    4.13     15.24       5.22     18.53      9.27     26.03      2.59
   2  MIN    6.22     21.09       7.47     24.93     12.16     33.09      4.30
   4  MIN    9.87     26.86      12.23     33.03     17.72     42.19     10.39
   8  MIN   12.30     30.11      15.02     36.94     20.04     45.66     15.24
-------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.85
MEASURED % ASH IN FEED:  11.74
-------------------------------
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION:    TEST#  11            DATE:13   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
           +200 MESH                -200/+325              -325 MESH
   TIME     WT%        % ASH       WT%       % ASH       WT%       % ASH
------------------------------------------------------------------------
  30 SEC   40.44       7.36       45.41       7.45      36.82       7.53
  1  MIN   17.70       7.08       15.04       7.42      19.00       7.50
  2  MIN    8.65       7.80        7.95       7.75      10.14       7.93
  4  MIN    2.49       8.90        3.45       9.00       3.88       8.91
  8  MIN    2.54      10.28        3.03       9.93       3.65       9.96
  TAIL     28.18      19.11       25.12      21.86      26.51      23.48
------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
------------------------------------------
  30 SEC   33.94        22.04      44.02
  1  MIN   33.11        16.27      50.61
  2  MIN   31.23        16.60      52.17
  4  MIN   24.86        19.95      55.19
  8  MIN   26.80        18.44      54.75
  TAIL     35.02        18.06      46.92
------------------------------------------
  FEED     33.30        19.26      47.44
------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH             -200/+325            -325 MESH
   TIME    %ASH       %ORG       %ASH      %ORG       %ASH      %ORG       WATER
----------------------------------------------------------------------------------
  30 SEC   27.88      41.98      30.16     47.34      23.23     38.67       4.10
  1  MIN   39.31      60.41      40.11     63.02      35.17     58.62       5.92
  2  MIN   45.56      69.35      45.60     71.28      41.91     69.22       7.74
  4  MIN   47.62      71.89      48.37     74.82      44.80     73.24      10.84
  8  MIN   50.05      74.45      51.05     77.89      47.85     76.97      15.05
----------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY
------------------------------
CALCULATED %ASH IN FEED:  11.41
MEASURED % ASH IN FEED:   11.82
------------------------------
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION.    TEST#  12            DATE:14   MONTH. 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA
-------------------------------------
           +200 MESH                -200/+325              -325 MESH
   TIME     WT%        % ASH       WT%       % ASH       WT%       % ASH
------------------------------------------------------------------------
  30 SEC   44.44       6.75       42.04       6.84      40.74       7.06
  1  MIN    7.34       6.76        5.55       6.57       6.36       7.30
  2  MIN    7.44       7.57        7.84       7.50       8.54       8.05
  4  MIN   11.14       8.48       13.91       8.57      15.09       8.77
  8  MIN    6.59       8.66        8.96       8.63       7.55       9.05
  TAIL     23.05      23.26       21.70      25.64      21.72      28.47
------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
------------------------------------------
  30 SEC   34.81        18.24      46.95
  1  MIN   37.12        15.56      47.32
  2  MIN   30.57        17.83      51.59
  4  MIN   27.14        18.77      54.09
  8  MIN   29.08        21.89      49.03
  TAIL     34.39        17.93      47.69
------------------------------------------
  FEED     33.06        18.31      48.64
------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH             -200/+325            -325 MESH
   TIME    %ASH       %ORG       %ASH      %ORG       %ASH      %ORG       WATER
----------------------------------------------------------------------------------
  30 SEC   27.42      46.53      25.32     44.18      23.53     43.14       3.32
  1  MIN   31.96      54.22      28.53     50.04      27.33     49.85       5.57
  2  MIN   37.11      61.94      33.71     58.22      32.95     58.79       8.37
  4  MIN   45.75      73.38      44.20     72.56      43.78     74.47      12.28
  8  MIN   50.97      80.14      51.01     81.80      49.38     82.30      17.00
----------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY
------------------------------
CALCULATED %ASH IN FEED:  11.84
MEASURED % ASH IN FEED:   11.71
------------------------------
```

```
                ************************************
                *    SIZE FRACTION  STUDIES        *
                *  ON GREGG RIVER RESOURCES        *
                *           FINE COAL              *
                ************************************


IDENTIFICATION:    TEST#  13            DATE:15   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH              -200/+325            -325 MESH
    TIME     WT%        % ASH       WT%       % ASH      WT%       % ASH
--------------------------------------------------------------------------
   30 SEC    32.23       6.21      21.55      6.02      35.01       6.31
   1  MIN    24.29       5.58      26.20      5.82      28.29       5.55
   2  MIN     6.06       7.23       8.35      7.93       8.72       7.82
   4  MIN     5.42       7.51       9.61      7.71       9.05       8.20
   8  MIN     2.10      10.10       2.64     10.90       2.71       9.63
   TAIL      29.90      20.47      31.64     27.51      16.22      32.92
--------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
             +200 MESH  -200/+325  -325 MESH
--------------------------------------------
   30 SEC    38.57          12.08      49.35
   1  MIN    34.76          17.56      47.68
   2  MIN    29.95          19.32      50.73
   4  MIN    26.32          21.88      51.80
   8  MIN    32.20          18.94      48.86
   TAIL      46.86          23.22      29.92
--------------------------------------------
   FEED      37.80          17.70      44.51
--------------------------------------------

RECOVERY DATA:
--------------
             +200 MESH                -200/+325            -325 MESH
    TIME     %ASH        %ORG       %ASH      %ORG      %ASH      %ORG       WATER
------------------------------------------------------------------------------------
   30 SEC    16.43       34.03       8.82     23.34     19.82     36.89        3.14
   1  MIN    29.70       59.57      21.35     51.78     36.84     66.83        5.50
   2  MIN    33.99       65.63      26.36     60.63     42.79     75.67        7.72
   4  MIN    38.03       71.41      31.97     70.86     48.49     85.01       11.62
   8  MIN    40.10       73.51      34.14     73.57     51.84     87.77       15.54
------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED:  11.13
MEASURED % ASH IN FEED:   11.93
-------------------------------
```

```
                ************************************
                *    SIZE FRACTION  STUDIES        *
                *  ON GREGG RIVER RESOURCES        *
                *           FINE COAL              *
                ************************************


IDENTIFICATION:    TEST#  14            DATE:15   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH              -200/+325            -325 MESH
    TIME     WT%        % ASH       WT%       % ASH      WT%       % ASH
--------------------------------------------------------------------------
   30 SEC    41.32       5.82      48.92      6.20      50.15       6.72
   1  MIN    16.79       6.84      15.23      7.47      22.52       7.74
   2  MIN    11.19       8.34      10.40     11.05      10.79       8.75
   4  MIN    10.57       9.08      11.15      9.96       6.78      11.33
   8  MIN     3.08      11.74       2.53     14.07       2.71      14.11
   TAIL      17.04      28.66      11.76     38.61       7.05      44.85
--------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
             +200 MESH  -200/+325  -325 MESH
--------------------------------------------
   30 SEC    29.03          18.82      52.15
   1  MIN    28.71          14.27      57.02
   2  MIN    34.06          17.34      48.59
   4  MIN    39.56          22.88      37.56
   8  MIN    36.36          16.36      47.27
   TAIL      50.23          18.99      30.78
--------------------------------------------
   FEED      33.03          18.09      48.89
--------------------------------------------

RECOVERY DATA:
--------------
             +200 MESH                -200/+325            -325 MESH
    TIME     %ASH        %ORG       %ASH      %ORG      %ASH      %ORG       WATER
------------------------------------------------------------------------------------
   30 SEC    21.87       43.63      26.77     51.75     32.18     52.25        3.63
   1  MIN    32.69       61.13      36.81     67.64     45.80     75.47        6.12
   2  MIN    41.49       72.60      46.96     78.08     58.83     86.34        8.37
   4  MIN    50.53       83.36      56.77     89.40     66.17     93.06       12.52
   8  MIN    53.94       86.40      59.91     91.86     69.81     95.65       17.28
------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED:  10.68
MEASURED % ASH IN FEED:   11.88
-------------------------------
```

```
                        ********************************
                        *    SIZE FRACTION  STUDIES    *
                        *  ON GREGG RIVER RESOURCES    *
                        *          FINE COAL           *
                        ********************************

IDENTIFICATION:    TEST#  15            DATE:15   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH               -200/+325              -325 MESH
     TIME     WT%       % ASH       WT%       % ASH       WT%       % ASH
-------------------------------------------------------------------------
    30 SEC    33.72      7.36      37.93      7.04      35.86      7.21
    1  MIN    14.42      7.38      12.73      7.14      14.59      7.92
    2  MIN     4.50      6.07       5.09      6.39       4.67      8.38
    4  MIN    14.18      8.49      14.40      7.40      16.55      9.06
    8  MIN    13.19      8.72      12.42      8.70      11.81      9.82
    TAIL      19.98     24.36      17.43     23.49      16.52     30.11
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
              +200 MESH  -200/+325  -325 MESH
---------------------------------------------
    30 SEC    31.81         21.27       46.82
    1  MIN    34.16         17.88       47.97
    2  MIN    31.51         21.13       47.36
    4  MIN    31.04         18.68       50.26
    8  MIN    35.70         19.93       44.37
    TAIL      37.54         19.40       43.06
---------------------------------------------
    FEED      33.55         19.89       46.56
---------------------------------------------

RECOVERY DATA:
--------------
              +200 MESH                -200/+325              -325 MESH
     TIME     %ASH       %ORG       %ASH       %ORG       %ASH       %ORG       WATER
-------------------------------------------------------------------------------------
    30 SEC    22.30      35.15      26.05      39.28      21.84      37.50       2.29
    1  MIN    31.85      50.18      34.93      52.45      31.66      52.72       4.05
    2  MIN    35.12      54.84      39.10      57.85      35.13      57.78       6.29
    4  MIN    45.93      69.44      45.51      72.51      47.88      74.85       8.85
    8  MIN    56.26      82.99      60.05      85.14      57.74      86.92      11.32
-------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED:  11.25
MEASURED % ASH IN FEED:   11.80
-------------------------------
```

```
                        ********************************
                        *    SIZE FRACTION  STUDIES    *
                        *  ON GREGG RIVER RESOURCES    *
                        *          FINE COAL           *
                        ********************************

IDENTIFICATION:    TEST#  16            DATE:18   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH               -200/+325              -325 MESH
     TIME     WT%       % ASH       WT%       % ASH       WT%       % ASH
-------------------------------------------------------------------------
    30 SEC    51.96      8.70      57.49      8.70      48.18      8.50
    1  MIN    16.01      9.98      13.29     10.09      17.71      9.06
    2  MIN     6.08      9.70       7.58      9.15       7.09      8.90
    4  MIN    10.90     10.53       8.90      9.95      11.08      9.84
    8  MIN     5.88     11.72       4.81     11.54       5.70     11.04
    TAIL       9.18     24.20       7.84     27.52      10.25     34.64
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
              +200 MESH  -200/+325  -325 MESH
---------------------------------------------
    30 SEC    31.45         22.82       45.73
    1  MIN    30.51         16.60       52.90
    2  MIN    27.36         22.64       50.00
    4  MIN    31.95         17.11       50.93
    8  MIN    32.67         17.57       49.77
    TAIL      30.21         16.92       52.87
---------------------------------------------
    FEED      31.02         20.34       48.64
---------------------------------------------

RECOVERY DATA:
--------------
              +200 MESH                -200/+325              -325 MESH
     TIME     %ASH       %ORG       %ASH       %ORG       %ASH       %ORG       WATER
-------------------------------------------------------------------------------------
    30 SEC    42.00      53.16      46.96      58.74      35.30      49.67       4.52
    1  MIN    56.63      69.32      59.56      72.11      49.14      68.09       6.33
    2  MIN    62.31      75.48      66.18      78.91      54.58      75.40       7.62
    4  MIN    72.97      85.40      74.51      88.88      63.98      86.68       9.59
    8  MIN    79.36      92.20      79.72      93.64      69.40      92.42      13.07
-------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED:  11.15
MEASURED % ASH IN FEED:   11.79
-------------------------------
```

```
                  ********************************
                  *    SIZE FRACTION  STUDIES    *
                  *  ON GREGG RIVER RESOURCES    *
                  *          FINE COAL           *
                  ********************************

IDENTIFICATION   TEST#  17            DATE:18   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
------------------------------------
            +200 MESH               -200/+325           -325 MESH
    TIME     WT%       % ASH      WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
   30 SEC   33.37      6.21      44.73      6.95      42.69      8.63
   1  MIN   19.82      7.11      18.76      8.67      17.88      9.62
   2  MIN   21.91      8.60      19.16      9.69      23.40     10.19
   4  MIN    5.87      8.65       5.19     10.31       9.55     11.10
   8  MIN    0.98     18.03       0.82     21.66       1.38     21.83
   TAIL     18.05     26.73      11.24     38.67       5.00     47.75
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   32.30        24.15      43.56
   1  MIN   40.25        21.26      38.49
   2  MIN   38.26        18.67      43.08
   4  MIN   31.15        15.38      53.48
   8  MIN   33.24        17.45      49.31
   TAIL     61.01        21.18      17.81
-------------------------------------------
   FEED     38.28        21.36      40.36
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH               -200/+325           -325 MESH
    TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
--------------------------------------------------------------------------------
   30 SEC   19.06     35.12     26.83     47.12     31.92     44.10       9.39
   1  MIN   32.01     55.78     40.57     66.52     46.90     62.47      14.02
   2  MIN   49.33     78.24     56.48     86.10     67.54     85.22      17.02
   4  MIN   54.00     84.28     61.07     91.38     76.73     95.82      20.80
   8  MIN   55.63     86.16     62.78     92.20     79.32     97.05      25.13
--------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
------------------------------
CALCULATED %ASH IN FEED  11.31
MEASURED % ASH IN FEED   11.66
------------------------------
```

```
                  ********************************
                  *    SIZE FRACTION  STUDIES    *
                  *  ON GREGG RIVER RESOURCES    *
                  *          FINE COAL           *
                  ********************************

IDENTIFICATION    TEST#  18            DATE:19   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
------------------------------------
            +200 MESH               -200/+325           -325 MESH
    TIME     WT%       % ASH      WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
   30 SEC   22.64      6.04      40.92      6.49      37.58      8.16
   1  MIN   28.83      5.81      23.48      7.15      23.64      8.62
   2  MIN   16.40      6.52      16.30      8.94      17.28     10.34
   4  MIN    6.29      9.55       8.26     11.25       8.98     12.95
   8  MIN    2.26     14.26       1.60     19.14       2.36     18.48
   TAIL     23.58     26.28       9.45     39.73      10.16     42.98
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   18.38        26.49      55.13
   1  MIN   30.40        21.21      48.39
   2  MIN   27.05        21.43      51.52
   4  MIN   26.64        21.17      52.19
   8  MIN   29.02        16.35      54.63
   TAIL     47.66        15.22      37.12
-------------------------------------------
   FEED     27.75        22.12      50.14
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH               -200/+325           -325 MESH
    TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
--------------------------------------------------------------------------------
   30 SEC   11.60     24.11     24.65     42.89     23.89     38.59       8.54
   1  MIN   24.84     52.76     40.22     67.32     39.68     64.40      12.89
   2  MIN   33.92     70.13     53.74     83.95     53.60     82.17      15.70
   4  MIN   40.64     78.63     62.35     92.17     62.57     91.14      20.55
   8  MIN   43.36     80.83     65.19     93.62     66.96     93.35      24.63
--------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
------------------------------
CALCULATED %ASH IN FEED  12.08
MEASURED % ASH IN FEED   11.82
------------------------------
```

```
                *********************************
                *    SIZE FRACTION  STUDIES      *
                *  ON GREGG RIVER RESOURCES      *
                *           FINE COAL            *
                *********************************

IDENTIFICATION:   TEST#  19          DATE:20   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH               -200/+325              -325 MESH
   TIME       WT%       % ASH        WT%       % ASH        WT%       % ASH
-----------------------------------------------------------------------------
   30 SEC    28.68       7.31       21.62       9.35       36.67       7.41
   1  MIN    27.77       7.65       41.10       7.85       22.55       8.41
   2  MIN    13.24       8.43       11.00      10.04       18.82       9.83
   4  MIN     5.07      12.58        5.45      14.42        5.90      15.25
   8  MIN     4.36      12.11        4.29      14.88        2.92      18.11
   TAIL      20.88      18.86       16.54      28.99       13.13      32.01
-----------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
              +200 MESH   -200/+325   -325 MESH
-----------------------------------------------
   30 SEC    30.57          12.37        57.06
   1  MIN    33.56          26.67        39.77
   2  MIN    28.41          12.67        58.92
   4  MIN    30.52          17.61        51.87
   8  MIN    39.87          21.08        39.03
   TAIL      42.68          18.15        39.17
-----------------------------------------------
   FEED      33.38          17.92        48.71
-----------------------------------------------

RECOVERY DATA:
--------------
              +200 MESH               -200/+325              -325 MESH
   TIME       %ASH       %ORG        %ASH       %ORG        %ASH       %ORG        WATER
-------------------------------------------------------------------------------------------
   30 SEC    18.92      28.71       15.97      22.43       22.47      38.83         5.82
   1  MIN    40.09      56.37       40.67      65.88       38.14      62.13        11.46
   2  MIN    51.94      71.78       48.60      77.21       53.43      81.43        14.82
   4  MIN    57.99      76.74       55.82      82.55       60.88      87.12        19.36
   8  MIN    63.00      81.02       60.80      85.75       65.25      89.84        25.61
-------------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 11.67
MEASURED % ASH IN FEED:  11.80
-------------------------------
```

```
                *********************************
                *    SIZE FRACTION  STUDIES      *
                *  ON GREGG RIVER RESOURCES      *
                *           FINE COAL            *
                *********************************

IDENTIFICATION    TEST#  20          DATE:21   MONTH  4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH               -200/+325              -325 MESH
   TIME       WT%       % ASH        WT%       % ASH        WT%       % ASH
-----------------------------------------------------------------------------
   30 SEC    61.10       8.15       56.35       9.86       41.15      10.78
   1  MIN    17.75      10.05       20.00      11.75       24.83      10.98
   2  MIN    13.52      11.81       14.61      13.78       15.49      12.21
   4  MIN     3.08      11.01        4.03      13.21        5.08      12.07
   8  MIN     0.62      15.63        1.04      18.97        1.09      21.15
   TAIL       3.94      45.19        3.98      63.95       12.36      63.66
-----------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
              +200 MESH   -200/+325   -325 MESH
-----------------------------------------------
   30 SEC    52.09          16.39        31.52
   1  MIN    37.85          14.56        47.59
   2  MIN    41.70          15.37        42.92
   4  MIN    34.12          15.24        50.64
   8  MIN    31.65          18.14        50.21
   TAIL      24.02           8.27        67.70
-----------------------------------------------
   FEED      44.65          15.23        40.12
-----------------------------------------------

RECOVERY DATA:
--------------
              +200 MESH               -200/+325              -325 MESH
   TIME       %ASH       %ORG        %ASH       %ORG        %ASH       %ORG        WATER
-------------------------------------------------------------------------------------------
   30 SEC    47.03      62.77       43.67      58.22       26.85      43.98        14.59
   1  MIN    63.88      80.62       61.97      78.48       43.32      70.47        18.88
   2  MIN    75.06      93.94       77.64      92.93       54.77      86.76        22.47
   4  MIN    82.28      97.00       81.77      95.93       58.48      92.11        25.14
   8  MIN    83.19      97.59       83.30      97.90       59.87      93.14        27.90
-------------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 13.31
MEASURED % ASH IN FEED:  11.79
-------------------------------
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:    TEST#  21            DATE:22   MONTH: 4   YEAR:1983
...............


SIZE FREQUENCY PER MESH AND ASH DATA:
.....................................
              +200 MESH              -200/+325             -325 MESH
     TIME     WT%        % ASH      WT%        % ASH      WT%       % ASH
..........................................................................
     30 SEC   12.99       6.08     14.96        6.68     10.23        7.23
     1  MIN   20.48       5.94     27.15        6.78     31.90        7.34
     2  MIN   24.63       7.00     22.78        8.35     23.46        8.36
     4  MIN   16.21       9.68     11.78        9.46     10.63       11.26
     8  MIN    7.91      11.22      8.51       12.41      6.08       13.81
     TAIL     17.77      30.28     14.82       40.63     17.70       39.95
..........................................................................

SIZE FREQUENCY PER INCREMENT:
.............................
              +200 MESH  -200/+325  -325 MESH
..............................................
     30 SEC   41.22          23.02        35.76
     1  MIN   29.78          19.14        51.08
     2  MIN   40.04          17.96        42.00
     4  MIN   48.19          16.99        34.81
     8  MIN   42.22          22.04        35.74
     TAIL     39.98          16.17        43.85
..............................................
     FEED     38.66          18.76        42.58
..............................................

RECOVERY DATA:
..............
              +200 MESH              -200/+325             -325 MESH
     TIME     %ASH        %ORG       %ASH        %ORG      %ASH       %ORG        WATER
.........................................................................................
     30 SEC    6.83       13.80       7.73       16.03      5.23      11.06         4.16
     1  MIN   17.35       35.59      21.95       45.10     21.78      45.48         9.36
     2  MIN   32.26       61.49      36.65       69.08     35.64      70.53        15.14
     4  MIN   45.82       78.05      45.29       81.33     44.10      81.52        20.24
     8  MIN   53.49       85.99      53.46       89.89     50.03      87.62        27.46
.........................................................................................

BACK CALCULATION OF FEED ASSAY:
...............................
CALCULATED %ASH IN FEED:  12.93
MEASURED % ASH IN FEED:   11.85
...............................
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:    TEST#  22            DATE:23   MONTH: 4   YEAR:1983
...............


SIZE FREQUENCY PER MESH AND ASH DATA:
.....................................
              +200 MESH              -200/+325             -325 MESH
     TIME     WT%        % ASH      WT%        % ASH      WT%       % ASH
..........................................................................
     30 SEC   72.70       8.41     67.49        8.92     60.68       10.01
     1  MIN   11.72       9.83     10.53       10.71     12.98       11.35
     2  MIN    8.71      11.31     11.98       12.00      7.99       12.96
     4  MIN    3.51      13.64      5.21       14.18      3.75       19.66
     8  MIN    0.36      13.14      0.50       20.64      0.53       24.14
     TAIL      3.00      44.04      4.29       50.51     14.08       61.13
..........................................................................

SIZE FREQUENCY PER INCREMENT:
.............................
              +200 MESH  -200/+325  -325 MESH
..............................................
     30 SEC   45.49          21.34        33.16
     1  MIN   41.29          18.76        39.95
     2  MIN   40.07          27.83        32.10
     4  MIN   37.27          27.98        34.75
     8  MIN   33.33          23.81        42.86
     TAIL     17.19          12.41        70.40
..............................................
     FEED     42.04          21.25        36.72
..............................................

RECOVERY DATA:
..............
              +200 MESH              -200/+325             -325 MESH
     TIME     %ASH        %ORG       %ASH        %ORG      %ASH       %ORG        WATER
.........................................................................................
     30 SEC   60.45       74.08      51.92       69.53     33.65      66.64        16.01
     1  MIN   71.97       85.82      61.65       80.16     41.81      80.67        19.34
     2  MIN   81.72       94.41      74.04       92.08     47.55      89.16        23.61
     4  MIN   86.46       97.79      80.42       97.15     51.64      92.84        27.57
     8  MIN   86.92       98.13      81.32       97.60     52.34      93.32        30.56
.........................................................................................

BACK CALCULATION OF FEED ASSAY:
...............................
CALCULATED %ASH IN FEED:  13.34
MEASURED % ASH IN FEED:   11.79
...............................
```

```
                  ********************************
                  *   SIZE FRACTION  STUDIES     *
                  *  ON GREGG RIVER RESOURCES    *
                  *          FINE COAL           *
                  ********************************

IDENTIFICATION:   TEST#  23          DATE:24   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH             -200/+325            -325 MESH
   TIME     WT%       % ASH      WT%      % ASH      WT%       % ASH
---------------------------------------------------------------------
  30 SEC    35.92      9.41     49.81      8.43     38.51      9.49
  1  MIN    21.13      9.68     18.35      8.57     20.99      9.26
  2  MIN    21.04      9.07     11.28      9.24     14.89     10.59
  4  MIN     6.69     12.41      6.71     12.21      4.78     13.78
  8  MIN     3.17     12.83      3.41     14.34      2.72     15.70
  TAIL      12.05     21.10      9.44     25.02     18.11     28.13
---------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
  30 SEC    34.08         24.29       41.63
  1  MIN    38.43         18.08       43.48
  2  MIN    48.04         13.24       38.73
  4  MIN    42.90         22.14       34.96
  8  MIN    39.53         21.84       38.64
  TAIL      32.11         12.93       54.95
-------------------------------------------
  FEED      37.69         19.37       42.94
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH             -200/+325            -325 MESH
   TIME     %ASH      %ORG       %ASH      %ORG       %ASH      %ORG      WATER
-------------------------------------------------------------------------------
  30 SEC    30.42     36.60      41.72     50.84      27.00     40.32     10.06
  1  MIN    48.82     58.08      58.15     70.56      41.38     62.34     13.49
  2  MIN    65.99     79.60      67.41     82.09      53.01     77.74     17.40
  4  MIN    73.45     86.19      74.69     88.73      57.87     82.51     22.44
  8  MIN    77.12     89.30      79.03     92.02      61.03     85.16     27.44
-------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.16
MEASURED % ASH IN FEED:  11.87
-------------------------------



                  ********************************
                  *   SIZE FRACTION  STUDIES     *
                  *  ON GREGG RIVER RESOURCES    *
                  *          FINE COAL           *
                  ********************************

IDENTIFICATION:   TEST#  24          DATE:25   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH             -200/+325            -325 MESH
   TIME     WT%       % ASH      WT%      % ASH      WT%       % ASH
---------------------------------------------------------------------
  30 SEC    50.26      8.71     52.20      9.39     44.49      9.49
  1  MIN    20.11      9.53     21.27      9.85     26.38      8.10
  2  MIN    14.09     11.43     13.62     13.27      8.60     12.46
  4  MIN     7.81     12.52      6.63     13.06      4.68     16.87
  8  MIN     3.35     11.72      3.15     12.39      3.10     15.71
  TAIL      4.39      38.22      3.12     46.54     12.74     57.81
---------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
  30 SEC    39.25         25.36       35.39
  1  MIN    33.40         21.98       44.62
  2  MIN    44.96         27.06       27.97
  4  MIN    46.76         24.70       28.54
  8  MIN    39.55         23.16       37.30
  TAIL      22.72         10.06       67.22
-------------------------------------------
  FEED      37.87         23.56       38.57
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH             -200/+325            -325 MESH
   TIME     %ASH      %ORG       %ASH      %ORG       %ASH      %ORG      WATER
-------------------------------------------------------------------------------
  30 SEC    39.98     51.53      42.57     53.45      25.83     48.14     10.89
  1  MIN    57.48     71.96      60.78     75.13      40.51     76.81     15.39
  2  MIN    72.19     85.97      78.48     88.48      47.07     85.82     19.86
  4  MIN    81.11     93.64      84.00     95.00      51.90     90.47     25.00
  8  MIN    84.69     96.96      87.39     98.11      54.88     93.69     27.00
-------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 13.17
MEASURED % ASH IN FEED:  11.84
-------------------------------
```

```
                 *********************************
                 *    SIZE FRACTION  STUDIES     *
                 *  ON GREGG RIVER RESOURCES     *
                 *           FINE COAL           *
                 *********************************

IDENTIFICATION:    TEST#  25           DATE:25   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
               +200 MESH              -200/+325             -325 MESH
     TIME      WT%        % ASH      WT%        % ASH      WT%        % ASH
-----------------------------------------------------------------------------
    30 SEC     21.21       5.51      29.35       6.67      22.63       7.20
    1  MIN     25.59       5.81      26.30       6.83      28.18       7.71
    2  MIN     19.62       6.99      14.54       8.09      18.35       8.88
    4  MIN     14.87       8.65      15.81       9.36      12.77      10.93
    8  MIN      2.18      10.16       2.00      13.08       1.64      14.43
    TAIL       16.44      32.42      11.99      45.00      14.22      61.29
-----------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
               +200 MESH  -200/+325  -325 MESH
-----------------------------------------------
    30 SEC     34.54         22.88       42.57
    1  MIN     36.44         17.93       45.63
    2  MIN     41.98         14.90       43.12
    4  MIN     40.95         20.72       38.33
    8  MIN     44.17         19.43       36.40
    TAIL       43.51         15.19       41.30
-----------------------------------------------
    FEED       38.62         18.58       42.80
-----------------------------------------------

RECOVERY DATA:
--------------
               +200 MESH              -200/+325             -325 MESH
     TIME      %ASH       %ORG       %ASH       %ORG       %ASH       %ORG       WATER
----------------------------------------------------------------------------------------
    30 SEC     10.70      22.50      16.23      31.16      11.61      28.67       6.85
    1  MIN     24.54      49.53      31.11      59.02      27.31      57.38      13.06
    2  MIN     37.08      70.02      40.86      74.22      38.54      78.96      17.16
    4  MIN     49.21      85.33      52.12      90.52      48.15      90.26      20.65
    8  MIN     51.23      87.53      55.29      92.60      49.76      91.90      23.14
----------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED:  12.67
MEASURED % ASH IN FEED:   11.76
-------------------------------
```

```
                 *********************************
                 *    SIZE FRACTION  STUDIES     *
                 *  ON GREGG RIVER RESOURCES     *
                 *           FINE COAL           *
                 *********************************

IDENTIFICATION:    TEST#  26           DATE:25   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
               +200 MESH              -200/+325             -325 MESH
     TIME      WT%        % ASH      WT%        % ASH      WT%        % ASH
-----------------------------------------------------------------------------
    30 SEC     63.88       7.24      67.17       7.32      35.63      10.35
    1  MIN     15.11       8.88      14.05      10.37      13.09       9.33
    2  MIN      9.33       9.57       8.02      12.98      11.49      12.85
    4  MIN      2.75      10.59       4.44      13.52       8.84      15.88
    8  MIN      0.35      19.25       0.43      24.43       4.59      11.78
    TAIL        8.57      35.90       5.89      56.32      26.35      52.81
-----------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
               +200 MESH  -200/+325  -325 MESH
-----------------------------------------------
    30 SEC     56.56         26.21       17.22
    1  MIN     53.11         21.76       25.12
    2  MIN     48.76         18.47       32.77
    4  MIN     28.95         20.48       50.57
    8  MIN     11.48          6.28       82.24
    TAIL       33.54         10.15       56.30
-----------------------------------------------
    FEED       50.34         22.18       27.48
-----------------------------------------------

RECOVERY DATA:
--------------
               +200 MESH              -200/+325             -325 MESH
     TIME      %ASH       %ORG       %ASH       %ORG       %ASH       %ORG       WATER
----------------------------------------------------------------------------------------
    30 SEC     44.92      66.05      42.98      70.29      16.56      41.09      12.70
    1  MIN     57.95      81.40      55.71      84.61      22.07      56.35      16.01
    2  MIN     66.63      90.81      64.82      92.39      28.71      69.23      19.42
    4  MIN     69.47      93.56      70.07      96.72      35.01      78.80      24.12
    8  MIN     70.12      93.88      70.89      97.10      37.44      84.01      28.14
----------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED:  13.83
MEASURED % ASH IN FEED:   11.74
-------------------------------
```

```
                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:    TEST#  27            DATE:28   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
               +200 MESH            -200/+325           -325 MESH
     TIME      WT%       % ASH      WT%       % ASH     WT%       % ASH
-------------------------------------------------------------------------
    30 SEC     43.61      8.45     44.26      8.62     16.12      9.25
    1  MIN     15.62      8.77     18.18      9.15     16.97     10.88
    2  MIN     24.61      8.99     21.89      7.82     32.06     12.77
    4  MIN      7.76     11.37      8.92     12.69     10.38     11.01
    8  MIN      0.55     17.37      0.85     18.36      0.69     22.84
    TAIL        7.84     28.83      4.81     47.85     23.59     34.07
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
               +200 MESH  -200/+325  -325 MESH
---------------------------------------------
    30 SEC     61.59        25.64      12.77
    1  MIN     47.32        23.83      28.85
    2  MIN     47.71        17.41      34.88
    4  MIN     45.00        21.23      33.77
    8  MIN     36.51        27.01      36.48
    TAIL       34.03         8.55      57.42
---------------------------------------------
    FEED       50.73        20.81      28.46
---------------------------------------------

RECOVERY DATA:
--------------
               +200 MESH            -200/+325           -325 MESH
     TIME      %ASH      %ORG       %ASH      %ORG      %ASH      %ORG      WATER
------------------------------------------------------------------------------------
    30 SEC     35.13     44.61      34.72     49.42      8.69     17.87       8.21
    1  MIN     48.18     60.53      50.89     64.87     19.70     35.78      12.60
    2  MIN     69.27     85.55      65.85     87.57     44.09     69.40      18.37
    4  MIN     77.68     93.23      77.27     98.31     60.90     80.49      23.90
    8  MIN     78.60     93.75      78.98     97.17     52.10     81.31      27.78
------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.36
MEASURED % ASH IN FEED:  11.89
-------------------------------



                    ********************************
                    *    SIZE FRACTION  STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION:    TEST#  28            DATE:27   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
               +200 MESH            -200/+325           -325 MESH
     TIME      WT%       % ASH      WT%       % ASH     WT%       % ASH
-------------------------------------------------------------------------
    30 SEC     45.93      8.22     43.60      8.41     30.64     10.03
    1  MIN     24.73      8.76     19.22      8.25     19.21     10.39
    2  MIN     18.23     10.71     22.54      9.82     21.77     11.13
    4  MIN      5.20     11.18      6.42     10.00      7.18     11.88
    8  MIN      2.00     13.11      2.58     18.25      3.33     18.83
    TAIL        3.90     40.76      3.65   - 52.83     17.87     54.07
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
               +200 MESH  -200/+325  -325 MESH
---------------------------------------------
    30 SEC     53.45        22.00      24.55
    1  MIN     52.83        18.20      28.97
    2  MIN     39.04        24.01      36.95
    4  MIN     41.35        24.87      33.78
    8  MIN     36.49        20.79      42.72
    TAIL       21.43         8.88      69.69
---------------------------------------------
    FEED       46.54        20.62      32.84
---------------------------------------------

RECOVERY DATA:
--------------
               +200 MESH            -200/+325           -325 MESH
     TIME      %ASH      %ORG       %ASH      %ORG      %ASH      %ORG      WATER
------------------------------------------------------------------------------------
    30 SEC     37.42     48.03      34.45     44.69     18.50     33.74      10.28
    1  MIN     58.44     72.18      49.35     64.43     27.28     54.88      15.88
    2  MIN     75.30     89.34      70.13     87.17     40.32     78.84      20.15
    4  MIN     82.02     95.48      78.04     95.89     44.84     86.42      22.87
    8  MIN     84.57     97.42      81.87     98.07     47.84     89.87      24.35
------------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 13.09
MEASURED % ASH IN FEED:  11.77
-------------------------------
```

```
               ********************************
               *    SIZE FRACTION  STUDIES    *
               *  ON GREGG RIVER RESOURCES    *
               *          FINE COAL           *
               ********************************

IDENTIFICATION:   TEST#  29          DATE:27   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH             -200/+325            -325 MESH
    TIME      WT%       % ASH      WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
    30 SEC    48.91      7.82      45.48      8.70      33.08      9.70
    1  MIN    21.80      8.37      22.53     10.12      17.88     10.91
    2  MIN    14.43      8.75      15.18     10.02      14.78     10.51
    4  MIN     7.38      9.60       7.88     10.51       9.82     11.46
    8  MIN     1.97     13.83       3.16     16.61       2.80     16.78
    TAIL       5.51     38.45       5.77     46.94      21.82     47.82
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
              +200 MESH  -200/+325  -325 MESH
---------------------------------------------
    30 SEC    54.04        19.87      26.09
    1  MIN    50.36        20.48      29.15
    2  MIN    46.59        19.30      34.11
    4  MIN    42.21        17.28      40.51
    8  MIN    38.82        24.54      36.64
    TAIL      23.50         9.70      66.80
---------------------------------------------
    FEED      47.45        18.68      33.87
---------------------------------------------

RECOVERY DATA:
--------------
              +200 MESH             -200/+325            -325 MESH
    TIME      %ASH      %ORG       %ASH      %ORG       %ASH      %ORG      WATER
---------------------------------------------------------------------------------
    30 SEC    38.21     50.11      33.33     47.36      17.07     36.79     10.17
    1  MIN    56.44     72.31      52.43     70.35      27.33     56.19     14.89
    2  MIN    69.05     86.94      65.17     85.86      35.61     72.49     19.85
    4  MIN    76.13     94.35      71.83     93.66      41.64     83.31     24.34
    8  MIN    78.84     96.23      75.32     96.65      44.24     85.91     29.25
---------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 13.35
MEASURED % ASH IN FEED:  11.77
-------------------------------
```

```
               ********************************
               *    SIZE FRACTION  STUDIES    *
               *  ON GREGG RIVER RESOURCES    *
               *          FINE COAL           *
               ********************************

IDENTIFICATION.   TEST#  30          DATE.26   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
              +200 MESH             -200/+325            -325 MESH
    TIME      WT%       % ASH      WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
    30 SEC    53.46      7.56      56.07      8.17      45.08      9.77
    1  MIN    25.65      8.67      22.15      9.74      15.73     11.52
    2  MIN     7.52     14.42       7.01     13.72       7.42     14.86
    4  MIN     7.84     12.78       8.32     16.77      11.46     16.76
    8  MIN     0.67     18.96       1.12     26.67       2.99     31.07
    TAIL       4.86     42.37       5.32     48.02      17.33     56.30
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
              +200 MESH  -200/+325  -325 MESH
---------------------------------------------
    30 SEC    51.91        21.83      26.26
    1  MIN    58.25        20.25      21.50
    2  MIN    50.80        19.05      30.15
    4  MIN    42.71        18.73      38.56
    8  MIN    22.83        15.49      61.68
    TAIL      27.89        12.28      59.82
---------------------------------------------
    FEED      49.89        20.08      30.03
---------------------------------------------

RECOVERY DATA:
--------------
              +200 MESH             -200/+325            -325 MESH
    TIME      %ASH      %ORG       %ASH      %ORG       %ASH      %ORG      WATER
---------------------------------------------------------------------------------
    30 SEC    38.53     55.44      38.34     58.48      22.12     50.80     11.71
    1  MIN    59.65     81.62      56.39     81.19      31.21     68.17     16.10
    2  MIN    69.96     88.82      64.44     88.06      36.74     78.06     19.16
    4  MIN    79.23     96.26      76.12     95.83      46.38     87.97     24.79
    8  MIN    80.43     96.87      78.62     96.86      51.04     90.54     31.02
---------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 13.64
MEASURED % ASH IN FEED:  11.76
-------------------------------
```

```
                    ********************************
                    *   SIZE FRACTION  STUDIES     *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION:   TEST#  31            DATE:28   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH             -200/+325           -325 MESH
   TIME     WT%       % ASH     WT%     % ASH      WT%       % ASH
------------------------------------------------------------------------
    30 SEC    37.33      7.68     33.87      8.05     22.58      8.33
    1  MIN    21.25      8.58     21.48      9.21     25.45      8.40
    2  MIN    20.42      9.68     20.04     10.28     26.56      9.66
    4  MIN     6.03     11.52      5.87     11.81      4.34     12.78
    8  MIN     2.59     15.60      2.84     17.68      2.18     21.34
    TAIL      12.37     27.29     14.91     31.45     18.90     40.49
------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
    30 SEC    50.52        23.44        26.04
    1  MIN    39.42        20.36        40.23
    2  MIN    38.31        19.22        42.47
    4  MIN    45.54        26.52        27.94
    8  MIN    43.87        24.65        31.48
    TAIL      34.27        21.12        44.61
-------------------------------------------
    FEED      42.31        21.63        36.06
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH              -200/+325             -325 MESH
   TIME     %ASH       %ORG       %ASH       %ORG       %ASH       %ORG       WATER
--------------------------------------------------------------------------------
    30 SEC    25.68      38.79      21.35      35.71      12.29      24.44       7.11
    1  MIN    42.06      60.66      36.83      58.05      26.25      51.95      12.24
    2  MIN    59.82      81.41      52.96      78.65      43.38      80.23      18.09
    4  MIN    66.06      87.42      59.32      85.60      46.99      84.70      21.88
    8  MIN    69.68      89.88      63.25      88.28      50.02      86.72      26.76
--------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.99
MEASURED % ASH IN FEED:  11.81
-------------------------------
```

```
                    ********************************
                    *   SIZE FRACTION  STUDIES     *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION    TEST#  32            DATE:29   MONTH: 4   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
            +200 MESH             -200/+325           -325 MESH
   TIME     WT%       % ASH     WT%     % ASH      WT%       % ASH
------------------------------------------------------------------------
    30 SEC    48.56      9.04     55.58      9.60     26.14     13.29
    1  MIN    18.72     10.02     19.97     10.20     20.03     11.14
    2  MIN    24.77     10.58     18.64     10.85     28.29     11.78
    4  MIN     5.32     12.96      4.38     12.89      7.08     13.93
    8  MIN     0.08     31.82      0.03     34.38      0.84     44.45
    TAIL       2.54     44.54      1.40     64.88     17.61     75.00
------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
            +200 MESH  -200/+325  -325 MESH
-------------------------------------------
    30 SEC    49.94        32.59        17.47
    1  MIN    43.42        26.40        30.18
    2  MIN    46.07        19.76        34.18
    4  MIN    42.85        20.12        37.03
    8  MIN    12.86         2.86        84.28
    TAIL      17.22         5.39        77.40
-------------------------------------------
    FEED      45.06        25.66        29.28
-------------------------------------------

RECOVERY DATA:
--------------
            +200 MESH              -200/+325             -325 MESH
   TIME     %ASH       %ORG       %ASH       %ORG       %ASH       %ORG       WATER
--------------------------------------------------------------------------------
    30 SEC    40.88      49.48      49.71      56.29      14.72      29.67      12.61
    1  MIN    56.35      68.36      66.67      76.38      24.16      52.97      16.01
    2  MIN    62.77      93.17      87.50      94.99      38.29      85.65      20.59
    4  MIN    89.19      98.36      92.75      99.27      42.47      93.63      24.48
    8  MIN    89.44      98.42      92.86      99.29      44.06      94.24      30.29
--------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 14.50
MEASURED % ASH IN FEED:  11.85
-------------------------------
```

```
                    **********************************
                    *     SIZE FRACTION  STUDIES     *
                    *   ON GREGG RIVER RESOURCES     *
                    *           FINE COAL            *
                    **********************************

IDENTIFICATION:   CNTR#   1           DATE:28   MONTH: 3   YEAR:1983
----------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-----------------------------------------
           +200 MESH             -200/+325             -325 MESH
   TIME     WT%       % ASH      WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
   30 SEC   40.82      7.76      35.04     10.19      26.42      9.24
   1  MIN   29.18      8.39      40.52      8.80      31.53      8.63
   2  MIN   14.50     11.51       0.22     14.71      22.85     11.58
   4  MIN    7.93     12.85      12.63     12.57       9.13     13.71
   8  MIN    1.34      9.45       1.92     20.39       2.63     18.21
   TAIL      6.23     33.42       9.67     38.91       7.84     45.40
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   47.27         14.81      37.92
   1  MIN   35.14         17.81      47.05
   2  MIN   34.00          0.19      65.81
   4  MIN   33.24         19.32      47.45
   8  MIN   25.32         13.20      61.47
   TAIL     32.40         18.35      49.25
-------------------------------------------
   FEED     38.40,        14.01      47.59
-------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH             -200/+325             -325 MESH
   TIME     %ASH      %ORG       %ASH      %ORG       %ASH      %ORG      WATER
----------------------------------------------------------------------------------
   30 SEC   30.13     42.08      27.66     35.14      18.80     27.56      5.95
   1  MIN   53.42     71.95      55.28     78.57      39.75     60.66      9.13
   2  MIN   69.29     85.29      55.53     78.79      59.95     83.88     12.08
   4  MIN   78.99     94.01      67.83     91.46      69.59     92.73     17.11
   8  MIN   80.20     95.37      70.86     93.22      73.28     95.21     23.33
----------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 12.02
MEASURED % ASH IN FEED:  11.86
-------------------------------
```

```
                    **********************************
                    *     SIZE FRACTION  STUDIES     *
                    *   ON GREGG RIVER RESOURCES     *
                    *           FINE COAL            *
                    **********************************

IDENTIFICATION:   CNTR#   2           DATE:29   MONTH: 3   YEAR:1983
----------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-----------------------------------------
           +200 MESH             -200/+325             -325 MESH
   TIME     WT%       % ASH      WT%       % ASH      WT%       % ASH
-------------------------------------------------------------------------
   30 SEC   41.59      8.26      40.07      9.49      40.45      8.10
   1  MIN   26.37      8.10      31.63      8.89      28.24      8.82
   2  MIN   14.69      9.24       7.56     14.84      19.30     10.52
   4  MIN    6.18     11.19       8.97     12.44       6.61     11.79
   8  MIN    0.65     12.68       0.56     14.55       0.76     12.76
   TAIL      8.51     33.13      11.20     35.79       6.64     43.52
-------------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   33.92         13.50      52.58
   1  MIN   34.08         15.70      50.22
   2  MIN   30.24          6.43      63.32
   4  MIN   30.27         18.16      51.57
   8  MIN   31.49         11.05      57.46
   TAIL     35.89         19.52      44.59
-------------------------------------------
   FEED     33.26         13.74      53.00
-------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH             -200/+325             -325 MESH
   TIME     %ASH      %ORG       %ASH      %ORG       %ASH      %ORG      WATER
----------------------------------------------------------------------------------
   30 SEC   32.14     42.72      29.40     41.65      28.91     41.94      4.43
   1  MIN   53.65     71.91      51.16     74.75      48.88     68.98      6.76
   2  MIN   66.35     86.84      59.72     82.16      66.78     88.45      9.59
   4  MIN   72.82     92.98      68.35     91.19      73.66     95.02     11.57
   8  MIN   73.61     93.63      68.99     91.74      74.52     95.77     22.14
----------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED: 11.34
MEASURED % ASH IN FEED:  11.50
-------------------------------
```

```
                  ********************************
                  *   SIZE FRACTION  STUDIES     *
                  *  ON GREGG RIVER RESOURCES    *
                  *          FINE COAL           *
                  ********************************


IDENTIFICATION:   CNTR#   3          DATE:30   MONTH: 3   YEAR:1983
...............

SIZE FREQUENCY PER MESH AND ASH DATA:
....................................
             +200 MESH            -200/+325           -325 MESH
   TIME      WT%       % ASH      WT%      % ASH      WT%      % ASH
..........................................................................
   30 SEC   41.08      7.88      63.85      7.57     40.99      8.47
   1  MIN   28.94      8.38       4.73     14.57     31.22      9.13
   2  MIN   18.01     12.96       9.50     15.17     13.85     11.71
   4  MIN    4.29     12.25       7.11     15.97      5.07     14.31
   8  MIN    2.27     17.44       3.75     18.67      2.76     21.10
   TAIL      5.41     35.49      11.06     41.29      6.10     46.62
..........................................................................

SIZE FREQUENCY PER INCREMENT:
............................
             +200 MESH  -200/+325  -325 MESH
...........................................
   30 SEC   34.93        16.75       48.32
   1  MIN   39.28         1.98       58.74
   2  MIN   44.86         7.30       47.84
   4  MIN   31.75        16.24       52.01
   8  MIN   31.23        15.95       52.82
   TAIL     31.31        19.74       48.95
...........................................
   FEED     37.11        11.45       51.44
...........................................

RECOVERY DATA:
.............
             +200 MESH            -200/+325            -325 MESH
   TIME      %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
.................................................................................
   30 SEC   29.89     42.44     36.14     68.13     28.69     42.68      5.74
   1  MIN   52.22     72.18     41.29     72.79     52.25     74.96      8.81
   2  MIN   73.76     89.75     52.06     82.09     65.66     88.87     11.91
   4  MIN   78.62     93.99     60.56     88.99     71.68     93.81     16.03
   8  MIN   82.27     96.08     65.85     92.50     76.48     96.29     23.66
.................................................................................

BACK CALCULATION OF FEED ASSAY:
..............................
CALCULATED %ASH IN FEED: 11.77
MEASURED % ASH IN FEED:  11.69
..............................
```

```
                  ********************************
                  *   SIZE FRACTION  STUDIES     *
                  *  ON GREGG RIVER RESOURCES    *
                  *          FINE COAL           *
                  ********************************


IDENTIFICATION:   CNTR#   4          DATE:30   MONTH: 3   YEAR:1983
...............

SIZE FREQUENCY PER MESH AND ASH DATA:
....................................
             +200 MESH            -200/+325           -325 MESH
   TIME      WT%       % ASH      WT%      % ASH      WT%      % ASH
..........................................................................
   30 SEC   37.21      8.38      24.58      9.85     40.56      8.76
   1  MIN   27.59      8.29      28.30     10.52     28.74      8.34
   2  MIN   15.95      9.64      27.64      9.19     20.34      9.43
   4  MIN   11.50     11.12      10.25     15.68      7.17     14.12
   8  MIN    1.48     16.00       3.39     17.42      0.66     20.88
   TAIL      6.27     35.82       5.84     49.84      2.52     55.35
..........................................................................

SIZE FREQUENCY PER INCREMENT:
............................
             +200 MESH  -200/+325  -325 MESH
...........................................
   30 SEC   33.60         6.57       59.83
   1  MIN   33.27        10.11       56.62
   2  MIN   27.81        14.27       57.92
   4  MIN   43.82        11.57       44.61
   8  MIN   41.50        28.23       30.27
   TAIL     51.70        14.27       34.03
...........................................
   FEED     34.13        10.11       55.76
...........................................

RECOVERY DATA:
.............
             +200 MESH            -200/+325            -325 MESH
   TIME      %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
.................................................................................
   30 SEC   29.13     38.18     18.57     25.48     34.12     41.31      5.48
   1  MIN   50.49     66.51     41.41     54.60     57.13     70.72      8.41
   2  MIN   64.86     82.66     60.90     83.46     75.54     91.28     10.88
   4  MIN   76.82     94.11     73.15     93.41     85.26     98.16     15.72
   8  MIN   79.03     95.50     77.68     96.63     86.58     98.74     20.81
.................................................................................

BACK CALCULATION OF FEED ASSAY:
..............................
CALCULATED %ASH IN FEED: 10.78
MEASURED % ASH IN FEED:  11.71
..............................
```

```
*********************************
*   SIZE FRACTION  STUDIES      *
*  ON GREGG RIVER RESOURCES     *
*          FINE COAL            *
*********************************


IDENTIFICATION:   CNTR#   5          DATE:31   MONTH: 3   YEAR:1983
---------------

SIZE FREQUENCY PER MESH AND ASH DATA:
-------------------------------------
           +200 MESH            -200/+325          -325 MESH
   TIME     WT%      % ASH     WT%      % ASH     WT%      % ASH
-------------------------------------------------------------------
   30 SEC   40.70     7.81    47.68     8.44     36.53     8.87
   1  MIN   24.71     8.37    17.88    10.76     31.58     8.41
   2  MIN   18.28    10.63    14.25    13.21     16.88    10.91
   4  MIN    8.28    12.29     9.81    13.31      9.98    12.34
   8  MIN    1.36    20.85     2.40    24.16      1.46    27.69
   TAIL      6.68    35.90     7.98    41.40      3.54    51.43
-------------------------------------------------------------------

SIZE FREQUENCY PER INCREMENT:
-----------------------------
           +200 MESH  -200/+325  -325 MESH
------------------------------------------
   30 SEC   36.01        17.45      46.54
   1  MIN   31.84         9.53      58.63
   2  MIN   37.67        12.15      50.18
   4  MIN   31.01        15.18      53.81
   8  MIN   30.56        22.22      47.22
   TAIL     44.33        21.88      33.80
------------------------------------------
   FEED     35.05        14.49      50.46
------------------------------------------

RECOVERY DATA:
--------------
           +200 MESH              -200/+325           -325 MESH
   TIME     %ASH      %ORG      %ASH      %ORG      %ASH      %ORG      WATER
------------------------------------------------------------------------------
   30 SEC   29.19     42.11     30.91     50.20     28.93     37.49      5.83
   1  MIN   48.18     67.52     45.68     68.54     52.67     70.07      8.64
   2  MIN   66.00     85.83     60.15     82.76     69.13     87.02     11.55
   4  MIN   75.35     93.98     70.18     92.53     80.12     96.87     14.70
   8  MIN   77.87     95.19     74.63     94.62     83.74     98.06     22.77
------------------------------------------------------------------------------

BACK CALCULATION OF FEED ASSAY:
-------------------------------
CALCULATED %ASH IN FEED  11.35
MEASURED % ASH IN FEED   11.67
-------------------------------
```

The Modelling Tests

```
                    **********************************
                    *   BATCH FLOTATION STUDIES      *
                    *   ON GREGG RIVER RESOURCES     *
                    *           FINE COAL            *
                    **********************************


IDENTIFICATION: BLOCK#  7     TEST#  1     DATE:   MAY  31 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR          -1        3.0        L/MIN.
COLLECT.     -1        0.2        L/TONNE
FROTHER      -1        0.15       L/TONNE
CONDIT.      -1        1.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  71.0     RESERVOIR WATER ADDED(G)= 146.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %       WT. %       CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH         SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                       % SOLIDS    ASH         SOLIDS
---------------------------------------------------------------------------
 0.50       11.01      5.03       19.27       11.01        5.03       19.27
 1.00        5.74      5.09       15.76       16.75        5.05       17.90
 2.00        4.53      4.87        9.59       21.28        5.01       15.11
 4.00        4.30      5.06        6.82       25.58        5.02       12.55
 8.00        6.48      5.61        7.07       32.05        5.14       10.85
---------------------------------------------------------------------------
TAILINGS    67.95     15.39        2.42       N/A          N/A         N/A
---------------------------------------------------------------------------
FEED       100.00     12.09        3.22      100.00       12.09        N/A
---------------------------------------------------------------------------
                                             MEASURED: 11.92
                                             -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH         WATER
TIME
----------------------------------------
 0.50       11.89      4.58        1.53
 1.00       18.09      7.00        2.55
 2.00       22.99      8.82        3.97
 4.00       27.63     10.62        5.93
 8.00       34.59     13.63        8.78
----------------------------------------




                    **********************************
                    *   BATCH FLOTATION STUDIES      *
                    *   ON GREGG RIVER RESOURCES     *
                    *           FINE COAL            *
                    **********************************


IDENTIFICATION: BLOCK#  7     TEST#  2     DATE:   MAY  31 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR           1        7.0        L/MIN
COLLECT.     -1        0.2        L/TONNE
FROTHER      -1        0.15       L/TONNE
CONDIT.      -1        1.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)=  82.7
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %       WT. %       CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH         SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                       % SOLIDS    ASH         SOLIDS
---------------------------------------------------------------------------
 0.50       21.30      4.89       26.60       21.30        4.89       26.60
 1.00        8.38      4.97       19.56       29.68        4.91       24.16
 2.00        6.66      5.07       16.54       36.34        4.94       22.28
 4.00        6.02      5.36       11.58       42.36        5.00       19.69
 8.00        5.25      6.54        5.22       47.61        5.17       15.08
---------------------------------------------------------------------------
TAILINGS    52.39     17.64        1.86       N/A          N/A         N/A
---------------------------------------------------------------------------
FEED       100.00     11.72        3.20      100.00       11.72        N/A
---------------------------------------------------------------------------
                                             MEASURED: 11.73
                                             -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH         WATER
TIME
----------------------------------------
 0.50       22.95      8.89        1.94
 1.00       31.96     12.45        3.08
 2.00       39.13     15.33        4.19
 4.00       45.58     18.08        5.71
 8.00       51.14     21.01        6.68
----------------------------------------
```

```
                        **********************************
                        *  BATCH FLOTATION STUDIES       *
                        *  ON GREGG RIVER RESOURCES      *
                        *          FINE COAL             *
                        **********************************


IDENTIFICATION: BLOCK#  7     TEST#  3     DATE:   JUNE  7 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT.      1       3.0        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS      0       6.0        %
RPM           0       1100.0
PH            0       8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  71.0     RESERVOIR WATER ADDED(G)=  28.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                    % SOLIDS   ASH        SOLIDS
----------------------------------------------------------------------
 0.50      11.68      5.19      24.09      11.68      5.19      24.09
 1.00       4.93      5.53      14.32      16.61      5.29      20.03
 2.00       4.61      5.47      10.19      21.22      5.33      16.56
 4.00       5.30      5.30       8.44      26.52      5.32      13.89
 8.00       7.17      5.44       6.21      33.69      5.35      11.00
----------------------------------------------------------------------
TAILINGS  66.31      15.19       2.43      N/A        N/A       N/A
----------------------------------------------------------------------
FEED      100.00     11.89       3.30     100.00     11.89      N/A
----------------------------------------------------------------------
                                          MEASURED: 11.90
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      12.57      5.10       1.26
 1.00      17.85      7.40       2.26
 2.00      22.80      9.52       3.64
 4.00      28.50     11.88       5.60
 8.00      36.20     15.16       9.30
----------------------------------------
```

```
                        **********************************
                        *  BATCH FLOTATION STUDIES       *
                        *  ON GREGG RIVER RESOURCES      *
                        *          FINE COAL             *
                        **********************************


IDENTIFICATION: BLOCK#  7     TEST#  4     DATE:   JUNE  1 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT.      1       3.0        L/TONNE
FROTHER      -1       0.15       L/TONNE
CONDIT.      -1       1.0        MINUTES
% SOLIDS      0       6.0        %
RPM           0       1100.0
PH            0       8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)=  54.3
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                    % SOLIDS   ASH        SOLIDS
----------------------------------------------------------------------
 0.50      28.41      4.95      40.95      28.41      4.95      40.95
 1.00       6.98      5.36      18.20      35.39      5.03      32.85
 2.00       8.15      7.09      15.12      43.54      5.42      28.84
 4.00       5.74      7.48      11.15      49.28      5.66      23.13
 8.00       4.92      7.62       6.57      54.20      5.84      17.98
----------------------------------------------------------------------
TAILINGS  45.80      19.15       1.68      N/A        N/A       N/A
----------------------------------------------------------------------
FEED      100.00     11.95       3.30     100.00     11.95      N/A
----------------------------------------------------------------------
                                          MEASURED: 11.98
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      30.67     11.76       1.60
 1.00      38.17     14.90       2.47
 2.00      46.77     19.73       4.03
 4.00      52.80     23.32       5.59
 8.00      57.97     26.46       8.44
----------------------------------------
```

```
                 ********************************
                 *   BATCH FLOTATION STUDIES    *
                 *  ON GREGG RIVER RESOURCES    *
                 *          FINE COAL           *
                 ********************************

IDENTIFICATION: BLOCK#  7     TEST#  5     DATE:   JUNE  1 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL      UNITS
            LEVEL       LEVEL
-----------------------------------------
AIR          -1         3.0         L/MIN.
COLLECT.     -1         0.2         L/TONNE
FROTHER       1         0.35        L/TONNE
CONDIT.      -1         1.0         MINUTES
% SOLIDS      0         6.0         %
RPM           0         1100.0
PH            0         6.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  68.0     RESERVOIR WATER ADDED(G)= 210.0
-------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %     CUM.        CUM.        CUM
INCREMENT SOLIDS %  ASH        SOLIDS    RECOVERED   WT. %       WT. %
(MIN.)                                   % SOLIDS    ASH         SOLIDS
------------------------------------------------------------------------
 0.50      25.44       5.34     24.71     25.44        5.34      24.71
 1.00      15.40       5.46     24.69     40.84        5.39      24.70
 2.00       9.50       5.72     15.66     50.34        5.45      22.28
 4.00       7.76       6.17     11.92     58.10        5.55      19.96
 6.00       5.24       7.69      4.57     63.33        5.72      15.62
------------------------------------------------------------------------
TAILINGS   36.67      20.72      1.24     N/A         N/A        N/A
------------------------------------------------------------------------
FEED      100.00      11.50      2.97    100.00       11.50      N/A
------------------------------------------------------------------------
                                         MEASURED: 11.79
                                         ---------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      27.21     11.81       2.37
 1.00      43.66     19.14       3.81
 2.00      53.76     23.86       5.36
 4.00      62.01     28.03       7.13
 6.00      67.47     31.46      10.47
----------------------------------------
```

```
                 ********************************
                 *   BATCH FLOTATION STUDIES    *
                 *  ON GREGG RIVER RESOURCES    *
                 *          FINE COAL           *
                 ********************************

IDENTIFICATION: BLOCK#  7     TEST#  6     DATE:   JUNE  1 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL      UNITS
            LEVEL       LEVEL
-----------------------------------------
AIR           1         7.0         L/MIN.
COLLECT.     -1         0.2         L/TONNE
FROTHER       1         0.35        L/TONNE
CONDIT.      -1         1.0         MINUTES
% SOLIDS      0         6.0         %
RPM           0         1100.0
PH            0         6.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 512.5
-------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %     CUM.        CUM.        CUM
INCREMENT SOLIDS %  ASH        SOLIDS    RECOVERED   WT. %       WT. %
(MIN.)                                   % SOLIDS    ASH         SOLIDS
------------------------------------------------------------------------
 0.50      38.25       6.01     24.84     38.25        6.01      24.84
 1.00      16.55       6.85     22.11     54.80        6.26      23.94
 2.00       9.99       7.42     14.10     64.80        6.44      21.82
 4.00       6.40       7.94      8.66     71.20        6.58      19.05
 6.00       5.33      10.37      3.53     76.53        6.84      14.59
------------------------------------------------------------------------
TAILINGS   23.47      27.32      0.76     N/A         N/A        N/A
------------------------------------------------------------------------
FEED      100.00      11.81      2.77    100.00       11.81      N/A
------------------------------------------------------------------------
                                         MEASURED: 11.97
                                         ---------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      40.77     19.47       3.30
 1.00      58.25     28.08       4.96
 2.00      66.74     35.36       6.70
 4.00      75.42     39.66       8.62
 6.00      80.64     44.34      12.77
----------------------------------------
```

```
                        ******************************
                        *  BATCH FLOTATION STUDIES   *
                        *  ON GREGG RIVER RESOURCES  *
                        *         FINE COAL          *
                        ******************************


IDENTIFICATION: BLOCK#  7     TEST#  7     DATE:   JUNE  2 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR           -1       3.0        L/MIN.
COLLECT        1       3.0        L/TONNE
FROTHER        1       0.35       L/TONNE
CONDIT.       -1       1.0        MINUTES
% SOLIDS       0       6.0        %
RPM            0       1100.0
PH             0       6.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  67.0     RESERVOIR WATER ADDED(G)= 413.3
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.        CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                    % SOLIDS   ASH         SOLIDS
-------------------------------------------------------------------------
 0.50      28.92      5.71      24.65      28.92      5.71       24.65
 1.00      11.79      5.81      21.64      40.71      5.74       23.76
 2.00       9.87      6.02      17.10      50.58      5.80       22.08
 4.00       8.29      6.37      12.51      58.87      5.88       19.84
 8.00       5.50      8.03       4.66      64.37      6.06       15.75
-------------------------------------------------------------------------
TAILINGS   35.63     22.31       1.20      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.85       2.96     100.00      11.85      N/A
-------------------------------------------------------------------------
                                          MEASURED: 12.06
                                          --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       30.87     13.82       2.69
 1.00       43.58     19.55       3.98
 2.00       54.12     24.52       5.44
 4.00       62.94     26.94       7.20
 8.00       66.66     32.63      10.49
----------------------------------------




                        ******************************
                        *  BATCH FLOTATION STUDIES   *
                        *  ON GREGG RIVER RESOURCES  *
                        *         FINE COAL          *
                        ******************************


IDENTIFICATION: BLOCK#  7     TEST#  8     DATE:   JUNE  2 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
----------------------------------------
AIR            1       7.0        L/MIN.
COLLECT        1       3.0        L/TONNE
FROTHER        1       0.35       L/TONNE
CONDIT.       -1       1.0        MINUTES
% SOLIDS       0       6.0        %
RPM            0       1100.0
PH             0       6.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  69.0     RESERVOIR WATER ADDED(G)= 207.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.        CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                    % SOLIDS   ASH         SOLIDS
-------------------------------------------------------------------------
 0.50      37.24      6.45      26.53      37.24      6.45       26.53
 1.00      13.06      6.85      22.15      50.30      6.55       25.23
 2.00      13.73      7.28      20.42      64.03      6.71       24.02
 4.00      10.75      7.59      15.06      74.78      6.85       22.13
 8.00       3.70     11.09       3.07      78.49      7.05       17.12
-------------------------------------------------------------------------
TAILINGS   21.51     28.36       0.73      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.60       2.95     100.00      11.60      N/A
-------------------------------------------------------------------------
                                          MEASURED: 11.96
                                          --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50       39.50     20.34       3.13
 1.00       53.29     27.94       4.53
 2.00       67.73     36.41       6.15
 4.00       78.98     43.42       8.00
 8.00       82.71     46.90      11.54
----------------------------------------
```

```
                        ********************************
                        *  BATCH FLOTATION STUDIES     *
                        *  ON GREGG RIVER RESOURCES    *
                        *          FINE COAL           *
                        ********************************


IDENTIFICATION BLOCK#  7     TEST#  9     DATE:   JUNE  2 1983          TYPE:   MODELLING TESTS
--------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
--------------------------------------
AIR          -1        3.0        L/MIN.
COLLECT.     -1        0.2        L/TONNE
FROTHER      -1        0.15       L/TONNE
CONDIT.       1        5.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
--------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  87.0     RESERVOIR WATER ADDED(G)= 216.8
----------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-----------------------------------------------------------------------
 0.50      23.33       5.62     25.84      23.33       5.62      25.84
 1.00      16.71       5.67     27.67      40.04       5.64      26.57
 2.00       9.70       5.97     24.76      49.74       5.70      26.20
 4.00       7.63       6.07     17.93      57.37       5.75      24.68
 8.00       6.29       6.20     12.37      63.66       5.80      22.47
-----------------------------------------------------------------------
TAILINGS   36.34      22.04      2.63      N/A        N/A        N/A
-----------------------------------------------------------------------
FEED      100.00      11.84      6.00     100.00      11.84      N/A
-----------------------------------------------------------------------
                                           MEASURED: 11.99
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
--------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
--------------------------------------
 0.50      24.98     11.07       4.27
 1.00      42.85     19.07       7.08
 2.00      53.20     23.96       8.95
 4.00      61.34     27.87      11.18
 8.00      68.03     31.18      14.02
--------------------------------------




                        ********************************
                        *  BATCH FLOTATION STUDIES     *
                        *  ON GREGG RIVER RESOURCES    *
                        *          FINE COAL           *
                        ********************************


IDENTIFICATION BLOCK#  7     TEST# 10     DATE:   JUNE  3 1983          TYPE:   MODELLING TESTS
--------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
--------------------------------------
AIR           1        7.0        L/MIN.
COLLECT.     -1        0.2        L/TONNE
FROTHER      -1        0.15       L/TONNE
CONDIT.       1        5.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
--------------------------------------

MISCELLANEOUS DATA. TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)=1100.6
----------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
-----------------------------------------------------------------------
 0.50      32.78       6.33     22.15      32.78       6.33      22.15
 1.00      17.88       6.70     16.79      50.66       6.46      20.83
 2.00      12.46       7.70     12.48      63.12       6.71      18.39
 4.00       8.47       7.92     12.29      71.60       6.85      17.37
 8.00       3.32      10.04      5.09      74.92       6.99      15.70
-----------------------------------------------------------------------
TAILINGS   25.08      26.26      1.51      N/A        N/A        N/A
-----------------------------------------------------------------------
FEED      100.00      11.94      4.67     100.00      11.94      N/A
-----------------------------------------------------------------------
                                           MEASURED: 12.06
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
--------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
--------------------------------------
 0.50      34.87     17.37       5.65
 1.00      53.81     27.42       9.43
 2.00      66.88     35.46      13.72
 4.00      75.74     41.08      16.69
 8.00      78.13     43.87      19.72
--------------------------------------
```

```
                     ******************************
                     *  BATCH FLOTATION STUDIES   *
                     *  ON GREGG RIVER RESOURCES  *
                     *         FINE COAL          *
                     ******************************

IDENTIFICATION: BLOCK#  7     TEST# 11     DATE:   JUNE  3 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
------------------------------------------
AIR          -1        3.0        L/MIN.
COLLECT.      1        3.0        L/TONNE
FROTHER      -1        0.15       L/TONNE
CONDIT.       1        5.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  57.0     RESERVOIR WATER ADDED(G)= 865.8
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %      WT. %
(MIN.)                                     % SOLIDS    ASH        SOLIDS
------------------------------------------------------------------------
  0.50      24.56      6.13      26.13      24.56       6.13      26.13
  1.00      19.30      6.18      31.49      43.86       6.15      28.51
  2.00      10.27      6.42      28.35      54.13       6.20      28.48
  4.00       8.81      6.93      17.77      62.94       6.31      26.99
  8.00       6.39      7.87       9.49      69.32       6.45      23.08
------------------------------------------------------------------------
TAILINGS    30.68     24.07       1.91      N/A         N/A        N/A
------------------------------------------------------------------------
FEED       100.00     11.86       5.24     100.00      11.86       N/A
------------------------------------------------------------------------
                                           MEASURED: 11.87
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
------------------------------------------
FLOAT      ORGANICS   ASH        WATER
TIME
------------------------------------------
  0.50      26.16     12.69       3.47
  1.00      46.70     22.75       5.80
  2.00      57.61     28.31       7.17
  4.00      66.90     33.45       9.42
  8.00      73.58     37.69      12.79
------------------------------------------




                     ******************************
                     *  BATCH FLOTATION STUDIES   *
                     *  ON GREGG RIVER RESOURCES  *
                     *         FINE COAL          *
                     ******************************

IDENTIFICATION: BLOCK#  7     TEST# 12     DATE:   JUNE  3 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
------------------------------------------
AIR           1        7.0        L/MIN.
COLLECT.      1        3.0        L/TONNE
FROTHER      -1        0.15       L/TONNE
CONDIT.       1        5.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  65.0     RESERVOIR WATER ADDED(G)= 920.2
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %      WT. %
(MIN.)                                     % SOLIDS    ASH        SOLIDS
------------------------------------------------------------------------
  0.50      30.00      6.61      26.06      30.00       6.61      26.06
  1.00      19.83      7.07      27.79      49.83       6.80      26.72
  2.00      17.43      7.34      24.69      67.26       6.94      26.17
  4.00       7.96      8.32      14.63      75.22       7.08      24.16
  8.00       3.62     11.79       4.04      78.84       7.30      19.65
------------------------------------------------------------------------
TAILINGS    21.16     28.93       1.32      N/A         N/A        N/A
------------------------------------------------------------------------
FEED       100.00     11.99       5.00     100.00      11.99       N/A
------------------------------------------------------------------------
                                           MEASURED: 12.10
                                           --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
------------------------------------------
FLOAT      ORGANICS   ASH        WATER
TIME
------------------------------------------
  0.50      31.83     16.55       4.47
  1.00      52.77     28.25       7.19
  2.00      71.12     38.93       9.96
  4.00      79.41     44.45      12.42
  8.00      83.04     48.01      16.86
------------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  7     TEST# 13     DATE:    JUNE  8 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          -1       3.0        L/MIN.
COLLECT      -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT        1       5.0        MINUTES
% SOLIDS      0       6.0        %
RPM           0       1100.0
PH            0       8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 317.3
-----------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
---------------------------------------------------------------------------
 0.50      24.53       5.88     26.01      24.53       5.88      26.01
 1.00      19.84       5.98     30.05      44.37       5.93      27.88
 2.00      14.96       6.69     31.61      59.33       6.12      28.57
 4.00      11.29       7.40     25.81      70.62       6.32      28.28
 6.00       7.01       7.64     14.38      77.63       6.44      26.00
---------------------------------------------------------------------------
TAILINGS  22.37      30.90       1.59      N/A        N/A        N/A
---------------------------------------------------------------------------
FEED      100.00     11.89       5.88     100.00      11.89      N/A
---------------------------------------------------------------------------
                                           MEASURED: 11.88
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      26.21     12.13       4.35
 1.00      47.38     22.11       7.22
 2.00      63.22     30.52       8.24
 4.00      75.08     37.54      11.16
 6.00      82.44     42.05      13.77
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  7     TEST# 14     DATE:    JUNE  8 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR           1       7.0        L/MIN.
COLLECT      -1       0.2        L/TONNE
FROTHER       1       0.35       L/TONNE
CONDIT        1       5.0        MINUTES
% SOLIDS      0       6.0        %
RPM           0       1100.0
PH            0       8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  84.0     RESERVOIR WATER ADDED(G)= 789.2
-----------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
---------------------------------------------------------------------------
 0.50      27.20       6.50     24.15      27.20       6.50      24.15
 1.00      21.68       6.54     28.87      48.87       6.52      26.04
 2.00      27.15       8.00     26.12      76.02       7.05      26.07
 4.00       8.21       9.59     15.10      84.23       7.30      24.38
 6.00       2.81      14.88      3.87      87.04       7.54      20.78
---------------------------------------------------------------------------
TAILINGS  12.96      39.16       0.61      N/A        N/A        N/A
---------------------------------------------------------------------------
FEED      100.00     11.66       4.95     100.00      11.66      N/A
---------------------------------------------------------------------------
                                           MEASURED: 11.82
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      28.78     15.16       4.45
 1.00      51.72     27.33       7.23
 2.00      79.99     45.95      11.23
 4.00      88.39     52.70      13.63
 6.00      91.10     56.24      17.28
----------------------------------------
```

```
                      ********************************
                      *   BATCH FLOTATION STUDIES    *
                      *   ON GREGG RIVER RESOURCES   *
                      *          FINE COAL           *
                      ********************************


IDENTIFICATION: BLOCK#  7     TEST# 15     DATE:   JUNE  6 1983          TYPE:   MODELLING TESTS
***************


EXPERIMENTAL CONDITIONS:
************************
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
*****************************************
AIR           -1       3.0        L/MIN.
COLLECT.       1       3.0        L/TONNE
FROTHER        1       0.35       L/TONNE
CONDIT.        1       5.0        MINUTES
% SOLIDS       0       6.0        %
RPM            0       1100.0
PH             0       8.3
*****************************************

MISCELLANEOUS DATA: TORQUE(G)=  60.0     RESERVOIR WATER ADDED(G)= 153.2
******************

EXPERIMENTAL RESULTS:
*********************
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
*************************************************************************
 0.50       26.69      6.36      25.71      26.69      6.36      25.71
 1.00       20.10      6.49      28.69      46.80      6.43      26.81
 2.00       13.14      7.05      28.53      59.94      6.57      27.28
 4.00        8.68      7.73      21.24      68.61      6.71      26.31
 8.00       10.36      8.06      14.66      78.97      6.88      23.79
*************************************************************************
TAILINGS   21.03      30.47       1.56      N/A        N/A        N/A
*************************************************************************
FEED      100.00      11.89       5.83     100.00      11.88      N/A
*************************************************************************
                                           MEASURED: 11.92
                                           *******************

SLURRY COMPONENT RECOVERIES (MODELLING):
*****************************************
FLOAT       ORGANICS   ASH        WATER
TIME
*****************************************
 0.50       28.36      14.34      4.86
 1.00       49.70      25.33      8.01
 2.00       63.66      33.12     10.09
 4.00       72.64      38.76     12.12
 8.00       83.45      45.78     15.95
*****************************************
```

```
                      ********************************
                      *   BATCH FLOTATION STUDIES    *
                      *   ON GREGG RIVER RESOURCES   *
                      *          FINE COAL           *
                      ********************************


IDENTIFICATION: BLOCK#  7     TEST# 16     DATE:   JUNE  7 1983          TYPE:   MODELLING TESTS
***************


EXPERIMENTAL CONDITIONS:
************************
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
*****************************************
AIR            1       7.0        L/MIN.
COLLECT.       1       3.0        L/TONNE
FROTHER       -1       0.35       L/TONNE
CONDIT.        1       5.0        MINUTES
% SOLIDS       0       6.0        %
RPM            0       1100.0
PH             0       8.3
*****************************************

MISCELLANEOUS DATA: TORQUE(G)=  72.0     RESERVOIR WATER ADDED(G)=1078.1
******************

EXPERIMENTAL RESULTS:
*********************
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
*************************************************************************
 0.50       29.76      6.54      25.02      29.76      6.54      25.02
 1.00       26.53      6.80      27.44      56.29      6.66      26.11
 2.00       20.04      8.54      22.74      76.33      7.15      25.13
 4.00        7.74     10.10      15.06      84.07      7.43      23.88
 8.00        2.86     13.97       4.22      86.92      7.64      20.72
*************************************************************************
TAILINGS   13.08      37.97       0.80      N/A        N/A        N/A
*************************************************************************
FEED      100.00      11.78       4.85     100.00      11.78      N/A
*************************************************************************
                                           MEASURED: 11.88
                                           *******************

SLURRY COMPONENT RECOVERIES (MODELLING):
*****************************************
FLOAT       ORGANICS   ASH        WATER
TIME
*****************************************
 0.50       31.53      16.60      4.54
 1.00       59.56      31.60      8.12
 2.00       80.34      46.31     11.58
 4.00       88.23      52.94     13.89
 8.00       91.01      56.32     16.95
*****************************************
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  7     CNTR#  1     DATE:   JUNE 13 1983           TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
--------------------------------------
AIR          0       5.0        L/MIN.
COLLECT.     0       1.6        L/TONNE
FROTHER      0       0.25       L/TONNE
CONDIT.      0       3.0        MINUTES
% SOLIDS     0       6.0        %
RPM          0       1100.0
PH           0       8.3
--------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  69.0     RESERVOIR WATER ADDED(G)= 464.8
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.      CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED WT. %      WT. %
(MIN.)                                     % SOLIDS  ASH        SOLIDS
----------------------------------------------------------------------
 0.50      29.89      5.95      26.99      29.89      5.95      26.99
 1.00      19.59      6.06      27.07      49.48      5.99      27.02
 2.00       8.65      6.58      17.76      58.13      6.06      25.08
 4.00       7.89      6.71      12.99      66.01      6.15      22.57
 8.00       6.01      7.16       8.72      72.02      6.24      19.83
----------------------------------------------------------------------
TAILINGS  27.98      25.61       1.41      N/A        N/A        N/A
----------------------------------------------------------------------
FEED      100.00     11.80       4.26     100.00     11.80       N/A
----------------------------------------------------------------------
                                          MEASURED: 11.94
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
--------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
--------------------------------------
 0.50      31.88     15.06       3.60
 1.00      52.74     25.12       5.95
 2.00      61.90     29.94       7.73
 4.00      70.24     34.42      10.08
 8.00      76.57     36.07      12.88
--------------------------------------




                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  7     CNTR#  2     DATE:   JUNE  9 1983           TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
--------------------------------------
AIR          0       5.0        L/MIN.
COLLECT.     0       1.6        L/TONNE
FROTHER      0       0.25       L/TONNE
CONDIT.      0       3.0        MINUTES
% SOLIDS     0       6.0        %
RPM          0       1100.0
PH           0       8.3
--------------------------------------

MISCELLANEOUS DATA  TORQUE(G)=  66.0     RESERVOIR WATER ADDED(G)= 313.7
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.      CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED WT. %      WT. %
(MIN.)                                     % SOLIDS  ASH        SOLIDS
----------------------------------------------------------------------
 0.50      27.82      5.91      27.47      27.82      5.91      27.47
 1.00      21.53      6.01      30.24      49.35      5.95      28.61
 2.00      10.13      6.51      20.36      59.48      6.05      26.76
 4.00       7.50      6.63      15.61      66.98      6.11      24.78
 8.00       4.93      6.60       8.86      71.91      6.15      21.93
----------------------------------------------------------------------
TAILINGS  28.09      25.34       1.41      N/A        N/A        N/A
----------------------------------------------------------------------
FEED      100.00     11.70       4.32     100.00     11.70       N/A
----------------------------------------------------------------------
                                          MEASURED: 11.88
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
--------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
--------------------------------------
 0.50      29.85     14.06       3.32
 1.00      52.57     25.12       5.58
 2.00      63.29     30.76       7.35
 4.00      71.22     35.01       9.18
 8.00      76.44     37.79      11.66
--------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES     *
                    *  ON GREGG RIVER RESOURCES     *
                    *          FINE COAL            *
                    ********************************


IDENTIFICATION: BLOCK#  7     CNTR#  3     DATE:   JUNE  8 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
---------------------------------------
AIR          0       5.0        L/MIN.
COLLECT.     0       1.6        L/TONNE
FROTHER      0       0.25       L/TONNE
CONDIT.      0       3.0        MINUTES
% SOLIDS     0       6.0        %
RPM          0       1100.0
PH           0       8.3
---------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  66.0     RESERVOIR WATER ADDED(G)= 183.7
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
-------------------------------------------------------------------------------
 0.50      30.01      5.96      26.78      30.01        5.96       26.78
 1.00      19.99      6.14      28.65      50.00        6.03       27.50
 2.00       9.37      6.78      20.23      59.37        6.15       26.02
 4.00       9.02      7.23      15.73      68.39        6.29       23.95
 8.00       7.12      7.40      10.62      75.52        6.40       21.42
-------------------------------------------------------------------------------
TAILINGS   24.48     27.87       1.34      N/A         N/A         N/A
-------------------------------------------------------------------------------
FEED      100.00     11.78       4.58     100.00       11.78       N/A
-------------------------------------------------------------------------------
                                           MEASURED: 11.91
                                           ------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
---------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
---------------------------------------
 0.50      31.99     15.17       3.94
 1.00      53.26     25.59       6.33
 2.00      63.16     30.99       8.10
 4.00      72.65     36.53      10.42
 8.00      80.12     41.00      13.29
---------------------------------------




                    ********************************
                    *   BATCH FLOTATION STUDIES     *
                    *  ON GREGG RIVER RESOURCES     *
                    *          FINE COAL            *
                    ********************************


IDENTIFICATION: BLOCK#  7     CNTR#  4     DATE:   JUNE  9 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
---------------------------------------
AIR          0       5.0        L/MIN.
COLLECT.     0       1.6        L/TONNE
FROTHER      0       0.25       L/TONNE
CONDIT.      0       3.0        MINUTES
% SOLIDS     0       6.0        %
RPM          0       1100.0
PH           0       8.3
---------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  71.0     RESERVOIR WATER ADDED(G)= 221.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
-------------------------------------------------------------------------------
 0.50      35.96      5.96      27.76      35.96        5.96       27.76
 1.00      13.90      6.15      28.42      49.87        6.01       27.94
 2.00       8.08      6.63      17.05      57.94        6.10       25.66
 4.00       7.65      6.78      14.38      65.59        6.18       23.51
 8.00       6.09      6.52       8.95      71.68        6.21       20.65
-------------------------------------------------------------------------------
TAILINGS   28.32     25.70       1.52      N/A         N/A         N/A
-------------------------------------------------------------------------------
FEED      100.00     11.84       4.53     100.00       11.84       N/A
-------------------------------------------------------------------------------
                                           MEASURED: 11.96
                                           ------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
---------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
---------------------------------------
 0.50      38.36     18.10       4.44
 1.00      53.16     25.32       6.10
 2.00      61.72     29.84       7.96
 4.00      69.80     34.22      10.12
 8.00      76.27     37.57      13.06
---------------------------------------
```

```
                    *******************************
                    *  BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES   *
                    *          FINE COAL          *
                    *******************************


IDENTIFICATION: BLOCK#  7     CNTR#  5     DATE:   JUNE 13 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
----------------------------------------
AIR           0         5.0        L/MIN.
COLLECT.      0         1.5        L/TONNE
FROTHER       0         0.25       L/TONNE
CONDIT.       0         3.0        MINUTES
% SOLIDS      0         8.0        %
RPM           0         1100.0
PH            0         8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  73.0     RESERVOIR WATER ADDED(G)= 614.8
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT      RECOVERED WT. %      WT. %       CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                      % SOLIDS    ASH         SOLIDS
----------------------------------------------------------------------------
 0.50      34.31       5.90     27.30       34.31        5.90       27.30
 1.00      16.94       6.13     25.80       51.25        5.98       26.78
 2.00      10.26       6.54     21.15       61.52        6.07       25.84
 4.00       6.51       6.92     13.90       68.03        6.15       23.72
 8.00       4.21       7.64      7.85       72.25        6.24       21.22
----------------------------------------------------------------------------
TAILINGS   27.75      26.42      1.37       N/A          N/A        N/A
----------------------------------------------------------------------------
FEED      100.00      11.74      4.24      100.00       11.74       N/A
----------------------------------------------------------------------------
                                            MEASURED: 11.92
                                            -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      36.58     17.25       4.04
 1.00      54.59     26.05       6.20
 2.00      65.48     31.62       7.88
 4.00      72.34     35.65       9.67
 8.00      76.75     38.39      11.86
----------------------------------------
```

```
                    *******************************
                    *  BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES   *
                    *          FINE COAL          *
                    *******************************


IDENTIFICATION  BLOCK#  7     CNTR#  6     DATE:   JUNE 13 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
----------------------------------------
AIR           0         5.0        L/MIN.
COLLECT.      0         1.5        L/TONNE
FROTHER       0         0.25       L/TONNE
CONDIT.       0         3.0        MINUTES
% SOLIDS      0         8.0        %
RPM           0         1100.0
PH            0         8.3
----------------------------------------

MISCELLANEOUS DATA  TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 448.7
------------------

EXPERIMENTAL RESULTS:
--------------------
FLOAT      RECOVERED WT. %      WT. %       CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS      RECOVERED   WT. %       WT. %
(MIN.)                                      % SOLIDS    ASH         SOLIDS
----------------------------------------------------------------------------
 0.50      31.95       5.89     27.22       31.95        5.89       27.22
 1.00      21.89       6.11     28.27       53.84        5.98       27.84
 2.00       9.04       6.79     19.51       62.88        6.10       26.08
 4.00       8.30       7.19     14.36       71.18        6.22       23.81
 8.00       4.81       7.60      8.16       75.99        6.31       21.23
----------------------------------------------------------------------------
TAILINGS   24.01      27.27      1.18       N/A          N/A        N/A
----------------------------------------------------------------------------
FEED      100.00      11.32      4.18      100.00       11.32       N/A
----------------------------------------------------------------------------
                                            MEASURED: 11.30
                                            -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
 0.50      33.91     16.63       3.73
 1.00      57.08     28.44       6.15
 2.00      66.58     33.86       7.76
 4.00      75.27     39.13       9.93
 8.00      80.28     42.36      12.30
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  7     STAR#  1     DATE:   JUNE 17 1983           TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR          -1        3.0        L/MIN.
COLLECT.      0        1.8        L/TONNE
FROTHER       0        0.25       L/TONNE
CONDIT.       0        3.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  66.0     RESERVOIR WATER ADDED(G)= 179.6
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.        CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                    % SOLIDS   ASH         SOLIDS
-------------------------------------------------------------------------
 0.50      28.47      5.74      29.31      28.47      5.74       29.31
 1.00      17.61      5.78      31.70      46.08      5.76       30.18
 2.00       7.88      6.58      21.26      53.96      5.88       28.44
 4.00       7.62      6.76      14.99      61.58      5.99       25.59
 8.00       6.57      6.44       8.50      68.15      6.03       21.44
-------------------------------------------------------------------------
TAILINGS   31.85     23.77       1.72      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.86       4.81     100.00     11.86       N/A
-------------------------------------------------------------------------
                                          MEASURED: 12.04
                                          -----------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
 0.50       30.44     13.79       3.32
 1.00       48.26     22.38       5.18
 2.00       57.62     26.75       6.57
 4.00       65.69     31.10       8.68
 8.00       72.66     34.86      12.08
-----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  7     STAR#  2     DATE:   JUNE 17 1983           TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR           1        7.0        L/MIN.
COLLECT.      0        1.8        L/TONNE
FROTHER       0        0.25       L/TONNE
CONDIT.       0        3.0        MINUTES
% SOLIDS      0        6.0        %
RPM           0        1100.0
PH            0        8.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  67.0     RESERVOIR WATER ADDED(G)= 200.3
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.        CUM
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %       WT. %
(MIN.)                                    % SOLIDS   ASH         SOLIDS
-------------------------------------------------------------------------
 0.50      33.24      6.26      26.17      33.24      6.26       26.17
 1.00      13.83      6.71      25.59      47.06      6.39       26.00
 2.00       5.92      7.20      15.38      52.98      6.48       24.13
 4.00      13.77      7.47      18.54      66.75      6.69       22.72
 8.00       7.49      7.18      12.30      74.24      6.74       20.83
-------------------------------------------------------------------------
TAILINGS   25.76     27.02       1.36      N/A        N/A        N/A
-------------------------------------------------------------------------
FEED      100.00     11.98       4.46     100.00     11.98       N/A
-------------------------------------------------------------------------
                                          MEASURED: 11.99
                                          -----------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
 0.50       35.40     17.37       4.38
 1.00       50.05     25.12       6.26
 2.00       56.29     28.58       7.78
 4.00       70.77     37.27      10.60
 8.00       78.86     41.76      13.10
-----------------------------------------
```

```
                    *******************************
                    *  BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES   *
                    *         FINE COAL           *
                    *******************************


IDENTIFICATION: BLOCK#  7     STAR#  3     DATE:   JUNE 17 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          0        5.0        L/MIN.
COLLECT.    -1        0.2        L/TONNE
FROTHER      0        0.25       L/TONNE
CONDIT.      0        3.0        MINUTES
% SOLIDS     0        6.0        %
RPM          0        1100.0
PH           0        8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 842.1
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %     CUM.       CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS    RECOVERED  WT. %      WT. %
(MIN.)                                   % SOLIDS   ASH        SOLIDS
------------------------------------------------------------------------
 0.50      34.75      5.86      25.23     34.75      5.86      25.23
 1.00      20.67      6.55      23.38     55.42      6.12      24.51
 2.00       8.86      7.44      13.86     64.28      6.30      22.16
 4.00       5.60      8.48       7.85     69.88      6.47      19.23
 8.00       3.35     11.38       3.17     73.23      6.70      15.61
------------------------------------------------------------------------
TAILINGS  26.77     25.83       1.23     N/A        N/A        N/A
------------------------------------------------------------------------
FEED     100.00     11.87       3.78    100.00     11.87       N/A
------------------------------------------------------------------------
                                         MEASURED: 11.83
                                         --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH       WATER
TIME
----------------------------------------
 0.50      37.12     17.15      4.05
 1.00      55.04     26.55      6.71
 2.00      66.34     34.11      8.67
 4.00      74.15     38.11     11.53
 8.00      77.53     41.32     15.55
----------------------------------------
```

```
                    *******************************
                    *  BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES   *
                    *         FINE COAL           *
                    *******************************


IDENTIFICATION: BLOCK#  7     STAR#  4     DATE:   JUNE 16 1983          TYPE:   MODELLING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
----------------------------------------
AIR          0        5.0        L/MIN.
COLLECT.     1        3.0        L/TONNE
FROTHER      0        0.25       L/TONNE
CONDIT.      0        3.0        MINUTES
% SOLIDS     0        6.0        %
RPM          0        1100.0
PH           0        8.3
----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 519.7
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %     CUM.       CUM.       CUM
INCREMENT SOLIDS %  ASH        SOLIDS    RECOVERED  WT. %      WT. %
(MIN.)                                   % SOLIDS   ASH        SOLIDS
------------------------------------------------------------------------
 0.50      33.04      5.99      27.99     33.04      5.99      27.99
 1.00      15.28      6.23      23.86     48.32      6.07      26.54
 2.00      11.52      6.71      19.28     59.84      6.19      24.74
 4.00       8.35      6.79      13.67     68.19      6.27      22.51
 8.00       5.10      7.44       7.65     73.29      6.35      19.83
------------------------------------------------------------------------
TAILINGS  26.71     25.50       1.34     N/A        N/A        N/A
------------------------------------------------------------------------
FEED     100.00     11.67       4.23    100.00     11.87       N/A
------------------------------------------------------------------------
                                         MEASURED: 11.87
                                         --------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH       WATER
TIME
----------------------------------------
 0.50      35.16     16.86      3.76
 1.00      51.38     25.13      5.91
 2.00      63.55     31.76      8.04
 4.00      72.36     36.62     10.37
 8.00      77.70     39.88     13.09
----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  7     STAR#  5     DATE:   JUNE 16 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR            0       5.0        L/MIN.
COLLECT        0       1.5        L/TONNE
FROTHER       -1       0.15       L/TONNE
CONDIT.        0       3.0        MINUTES
% SOLIDS       0       6.0        %
RPM            0       1100.0
PH             0       8.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 287.8
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
--------------------------------------------------------------------------
  0.50      29.26       5.57     27.41     29.26       5.57      27.41
  1.00      14.52       5.79     24.94     43.78       5.65      26.54
  2.00       8.21       6.08     16.58     51.99       5.72      24.24
  4.00       7.88       6.27     13.51     59.86       5.79      21.95
  8.00       4.97       6.14      7.80     64.83       5.82      19.27
--------------------------------------------------------------------------
TAILINGS   35.17      22.29      1.83     N/A         N/A        N/A
--------------------------------------------------------------------------
FEED      100.00      11.64      4.42    100.00      11.64       N/A
--------------------------------------------------------------------------
                                          MEASURED: 11.87
                                          ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
  0.50      31.27     14.01       3.58
  1.00      46.75     21.23       5.60
  2.00      55.47     25.53       7.51
  4.00      63.83     29.77       9.84
  8.00      69.10     32.39      12.56
-----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  7     STAR#  6     DATE:   JUNE 16 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED      ACTUAL     UNITS
            LEVEL      LEVEL
-----------------------------------------
AIR            0       5.0        L/MIN.
COLLECT        0       1.5        L/TONNE
FROTHER        1       0.35       L/TONNE
CONDIT.        0       3.0        MINUTES
% SOLIDS       0       6.0        %
RPM            0       1100.0
PH             0       8.3
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  89.0     RESERVOIR WATER ADDED(G)= 880.8
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.       CUM.       CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                     % SOLIDS   ASH        SOLIDS
--------------------------------------------------------------------------
  0.50      44.17       6.85     26.07     44.17       6.85      26.07
  1.00      23.00       7.88     23.90     67.17       7.20      25.28
  2.00      12.22       9.74     11.58     79.39       7.59      21.39
  4.00       5.32      11.63      5.01     84.71       7.84      17.74
  8.00       2.04      15.67      2.06     86.75       8.03      15.05
--------------------------------------------------------------------------
TAILINGS   13.25      35.71      0.61     N/A         N/A        N/A
--------------------------------------------------------------------------
FEED      100.00      11.74      3.62    100.00      11.74       N/A
--------------------------------------------------------------------------
                                          MEASURED: 11.78
                                          ---------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT       ORGANICS  ASH        WATER
TIME
-----------------------------------------
  0.50      46.62     25.78       4.70
  1.00      70.63     41.18       7.46
  2.00      83.13     51.33      10.96
  4.00      88.45     56.60      14.75
  8.00      90.40     59.36      18.39
-----------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  7     STAR#  7     DATE:   JUNE 20 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
------------------------------------------
AIR           0         5.0        L/MIN.
COLLECT.      0         1.6        L/TONNE
FROTHER       0         0.25       L/TONNE
CONDIT.      -1         1.0        MINUTES
% SOLIDS      0         6.0        %
RPM           0         1100.0
PH            0         8.3
------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  72.0     RESERVOIR WATER ADDED(G)= 479.4
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
--------------------------------------------------------------------------
 0.50       33.92      5.68      27.76      33.92       5.68       27.76
 1.00       11.37      5.97      20.00      45.29       5.75       25.30
 2.00        8.99      6.17      14.55      54.28       5.82       22.54
 4.00        8.22      6.72       9.99      62.50       5.94       19.35
 8.00        4.05      9.10       3.61      66.55       6.13       15.29
--------------------------------------------------------------------------
TAILINGS    33.45     24.23       1.12      N/A         N/A        N/A
--------------------------------------------------------------------------
FEED       100.00     12.05       2.92     100.00      12.05       N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.92
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
------------------------------------------
FLOAT       ORGANICS   ASH         WATER
TIME
------------------------------------------
 0.50       36.38      15.98        2.66
 1.00       48.54      21.62        4.02
 2.00       58.13      26.22        5.61
 4.00       66.85      30.80        7.84
 8.00       71.03      33.86       11.10
------------------------------------------
```

```
                    ********************************
                    *   BATCH FLOTATION STUDIES    *
                    *   ON GREGG RIVER RESOURCES   *
                    *          FINE COAL           *
                    ********************************

IDENTIFICATION: BLOCK#  7     STAR#  8     DATE:   JUNE 20 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR      CODED       ACTUAL     UNITS
            LEVEL       LEVEL
------------------------------------------
AIR           0         5.0        L/MIN.
COLLECT.      0         1.6        L/TONNE
FROTHER       0         0.25       L/TONNE
CONDIT.       1         5.0        MINUTES
% SOLIDS      0         6.0        %
RPM           0         1100.0
PH            0         8.3
------------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  70.0     RESERVOIR WATER ADDED(G)= 787.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT      RECOVERED WT. %      WT. %      CUM.        CUM.        CUM
INCREMENT  SOLIDS %  ASH        SOLIDS     RECOVERED   WT. %       WT. %
(MIN.)                                     % SOLIDS    ASH         SOLIDS
--------------------------------------------------------------------------
 0.50       30.18      6.92      25.49      30.18       6.92       25.49
 1.00       25.02      7.00      29.46      55.20       6.95       27.15
 2.00       21.49      8.29      25.26      76.69       7.33       26.60
 4.00        7.03      8.75      15.89      83.72       7.45       25.17
 8.00        2.33     12.42       3.70      86.05       7.58       21.76
--------------------------------------------------------------------------
TAILINGS    13.94     36.23       0.87      N/A         N/A        N/A
--------------------------------------------------------------------------
FEED       100.00     11.64       5.00     100.00      11.64       N/A
--------------------------------------------------------------------------
                                           MEASURED: 11.85
                                           -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
------------------------------------------
FLOAT       ORGANICS   ASH         WATER
TIME
------------------------------------------
 0.50       31.79      17.93        4.64
 1.00       58.13      32.97        7.79
 2.00       80.44      48.28       11.14
 4.00       87.70      53.56       13.10
 8.00       90.01      56.05       16.29
------------------------------------------
```

8. APPENDIX II

A Representative Example Of Data Processing Programs In Fortran

```
C     DATA PROCESSING PROGRAM FOR THE GREGG RIVER FLOTATION STUDIES
C     DEPARTMENT OF MINERAL ENGINEERING, THE UNIVERSITY OF ALBERTA.
C
C     PROGRAM AUTHORS:   B.C. FLINTOFF
C     ----------------   K. KIM
C                        JULY, 1983
C
C     COMMENTS:     THIS VERSION OF THE PROGRAM REQUIRES TWO SUB-
C     ---------     ROUTINES FROM THE IMSL PACKAGE (VMULFF &
C                   LINV2F) FOR THE NON-LINEAR REGRESSION ANALYSIS.
C                   THE PROCESS DATA FILE IS ATTACHED TO UNIT #5.
C
C------------------------------------------------------------------
C
      DIMENSION ROUGH(10,5),WT(10,3),ASH(30,3),BAL(10,6),REG(3,4),
     1          RECOV(10,3),XX(5),TIME(10)
      DIMENSION P2(2),Y(10),X(10,2),XT(2,10),XTX(2,2),XTY(2),
     1          XTXINV(2,2),DELP(2),WORK(50),SE(2)
      DIMENSION P3(3),W(10),Z(10,3),ZT(3,10),ZTZ(3,3),ZTW(3),
     1          ZTZINV(3,3),DELP3(3),SE3(3),PMIN(3),PMAX(3)
      DOUBLE PRECISION UNIT(10),IDF(10),LEVEL(10,3)
      INTEGER DATE(5),TYPE(5),CODE(10),IFLAG(3),FACT,BLK,TEST
      DATA LEVEL/'3.0     ','0.2     ','0.15    ','1.0     ','3.0     ',
     1           '850.0   ','7.8     ','        ','        ','        ',
     2           '5.0     ','1.5     ','0.25    ','3.0     ','6.0     ',
     3           '1100.0  ','8.3     ','        ','        ','        ',
     4           '7.0     ','3.0     ','0.35    ','5.0     ','9.0     ',
     5           '1250.0  ','8.8     ','        ','        ','        '/
      DATA IDF/'AIR     ','COLLECT.','FROTHER ','CONDIT. ','% SOLIDS',
     1         'RPM     ','PH      ','        ','        ','        '/
      DATA UNIT/'L/MIN.  ','L/TONNE ','L/TONNE ','MINUTES ','%       ',
     1          '        ','        ','        ','        ','        '/
      DATA PMAX/99.9,10.,10./
      DATA PMIN/0.,.0001,.0001/
C--------------------------------------------------------------------
C
C      INPUT THE EXPERIMENTAL DATA
C
C
C   IDENTIFICATION INFO.
C
      READ(5,10)BLK,TEST
   10 FORMAT(3I5)
      READ(5,20)DATE
      READ(5,20)TYPE
   20 FORMAT(5A4)
C
C   FACTORS AND CODES
C
      READ(5,10)FACT
      READ(5,30)(CODE(I),I=1,FACT)
   30 FORMAT(10I2)
C
C   # OF FLOAT INCREMENTS AND COLLECTION TIMES
C
      READ(5,10)INC
      READ(5,40)(TIME(I),I=1,INC)
   40 FORMAT(10F6.1)
      INC1=INC+1
      INC2=INC+2
C
C   TORQUE MEASUREMENT AND RESERVOIR WATER ADDITION
C
      READ(5,50)TORQ,RESBEG,RESEND
   50 FORMAT(3F10.1)
C
C   WATER AND FLOTATION INCREMENT WEIGHT DATA
C
      READ(5,50)WASH
      READ(5,50)((WT(I,J),J=1,3),I=1,INC1)
C
C   ASH ANALYSIS WEIGHT DATA
C
      JJ=2*INC2
      READ(5,50)((ASH(I,J),J=1,3),I=1,JJ)
C
C  INPUT  IS  COMPLETE
C
C--------------------------------------------------------------
C
C
C      PERFORM THE BASIC (EXCLUDES KINETIC MODELLING) CALCULATIONS
C
C
C
9999  SOL=0.
      WAT=0.
      RESADD=RESBEG-RESEND
      WT(INC1,1)= WASH+RESADD
      DO 200 I=1,INC2
      IF(I.EQ.INC2)GOTO 210
      ROUGH(I,1)=WT(I,2)-WT(I,3)
      ROUGH(I,2)=WT(I,1)-WT(I,2)
      SOL=SOL+ROUGH(I,1)
      WAT=WAT+ROUGH(I,2)
  210 J1=(I-1)*2+1
      J2=J1+1
      J3=3
      DO 220 J=J1,J2
      ROUGH(I,J3)=100*(ASH(J,2)-ASH(J,3))/(ASH(J,1)-ASH(J,3))
      J3=4
  220 CONTINUE
      ROUGH(I,5)=(ROUGH(I,3)+ROUGH(I,4))/2.
  200 CONTINUE
      ROUGH(INC2,1)=SOL
      ROUGH(INC2,2)=WAT
C
C    COMPUTE METALLURGICAL BALANCE
C
      CUM1=0.
      CUM2=0.
      CUM3=0.
      DO 300 I=1,INC2
      BAL(I,1)=ROUGH(I,1)*100/ROUGH(INC2,1)
      BAL(I,2)=ROUGH(I,5)
      BAL(I,3)=100*ROUGH(I,1)/(ROUGH(I,1)+ROUGH(I,2))
      CUM1=CUM1+ROUGH(I,1)
      CUM2=CUM2+ROUGH(I,2)
      CUM3=CUM3+ROUGH(I,1)*ROUGH(I,5)
      BAL(I,4)=100.*CUM1/ROUGH(INC2,1)
      BAL(I,5)=CUM3/CUM1
      BAL(I,6)=100.*CUM1/(CUM1+CUM2)
  300 CONTINUE
C
C  COMPUTE THE SLURRY COMPONENT RECOVERY DATA
C
      CUM1=0.
      DO 400 I=1,INC
      CUM1=CUM1+ROUGH(I,2)
      RECOV(I,3)=100.*CUM1/ROUGH(INC2,2)
      RECOV(I,1)=BAL(I,4)*(100.-BAL(I,5))/(100.-BAL(INC2,5))
      RECOV(I,2)=BAL(I,4)*BAL(I,5)/BAL(INC2,5)
  400 CONTINUE
C
C  PERFORM SIMPLE LINEAR CORRELATION ANALYSIS
C
      ICNT=0
      DO 500 II=1,2
      IM=II+1
      DO 510 ID=IM,3
      ICNT=ICNT+1
      DO 520 I=1,5
  520 XX(I)=0.
      DO 530 I=1,INC
      XX(1)=XX(1)+RECOV(I,II)
      XX(2)=XX(2)+RECOV(I,ID)
      XX(3)=XX(3)+RECOV(I,II)**2
      XX(4)=XX(4)+RECOV(I,ID)**2
      XX(5)=XX(5)+RECOV(I,II)*RECOV(I,ID)
  530 CONTINUE
      RINC=FLOAT(INC)
      REG(ICNT,1)=(XX(5)-XX(1)*XX(2)/RINC)/(XX(3)-XX(1)**2/RINC)
      REG(ICNT,2)=XX(2)/RINC-REG(ICNT,1)*XX(1)/RINC
      SSM=XX(4)-XX(2)**2/RINC
      SSREG=REG(ICNT,1)*(XX(5)-XX(1)*XX(2)/RINC)
      REG(ICNT,4)=SSREG/SSM
      REG(ICNT,3)=(RINC-2.)*SSREG/(SSM-SSREG)
  510 CONTINUE
  500 CONTINUE
C-------------------------------------------------------------------
C
C     OUTPUT THE PRELIMINARY DATA
C--------------------------------------------------------------------
C
      WRITE(6,1000)
 1000 FORMAT('1',20X,31('*')/' ',20X,'*',2X,'BATCH FLOTATION STUDIES',
     1       4X,'*'/' ',20X,'*',2X,'ON GREGG RIVER RESOURCES',3X,'*',
     2       /' ',20X,'*',10X,'FINE COAL',10X,'*'/' ',20X,31('*')/)
      WRITE(6,1010)BLK,TEST,DATE,TYPE
 1010 FORMAT('-','IDENTIFICATION: BLOCK# ',I2,5X,'TEST# ',I2,5X,
     1       'DATE: ',5A4,5X,'TYPE: ',5A4/' ',15('-'))
      WRITE(6,1020)
 1020 FORMAT('-','EXPERIMENTAL CONDITIONS:'/' ',24('-'))
      WRITE(6,1030)
 1030 FORMAT(' ','FACTOR',4X,'CODED',5X,'ACTUAL',4X,'UNITS'/' ',
     1       10X,'LEVEL',5X,'LEVEL'/' ',40('-'))
      DO 1040 I=1,FACT
      JJ=2+CODE(I)
      WRITE(6,1050)IDF(I),CODE(I),LEVEL(I,JJ),UNIT(I)
 1050 FORMAT(' ',A6,4X,I2,6X,A6,2X,A6)

 1040 CONTINUE
      WRITE(6,1060)
 1060 FORMAT(' ',40('-'))
C
C MISCELLANEOUS DATA'
C
      WRITE(6,1200)TORQ,RESADD
 1200 FORMAT('0','MISCELLANEOUS DATA: TORQUE(G)=',F6.1,5X,'RESERVOIR',
     1       ' WATER ADDED(G)=',F6.1/' ',18('-'))
C
C METALLURGICAL BALANCE
C
      WRITE(6,1300)
 1300 FORMAT('0','EXPERIMENTAL RESULTS:'/' ',21('-')/' ','FLOAT',5X,
     1       'RECOVERED',1X,'WT. %',5X,'WT. %',5X,'CUM. ',6X,'CUM. ',6X,
     2       'CUM'/' ','INCREMENT',1X,'SOLIDS %',2X,'ASH',7X,
     3       'SOLIDS',4X,'RECOVERED ','WT. %',5X,'WT. %'/' ','(MIN.)',
     4       34X,'% SOLIDS',2X,'ASH',7X,'SOLIDS'/' ',70('-'))
      DO 1310 I=1,INC2
      IF(I.EQ.INC1) GOTO 1330
      IF(I.EQ.INC2) GOTO 1350
      WRITE(6,1320)TIME(I),(BAL(I,J),J=1,6)
 1320 FORMAT(' ',7(F5.2,5X))
      GOTO 1310
 1330 WRITE(6,1340)(BAL(I,J),J=1,3)
 1340 FORMAT(' ',70('-')/' ','TAILINGS',2X,3(F6.2,5X),3('N/A',7X))
      GOTO 1310
 1350 WRITE(6,1360)BAL(INC2,1),BAL(INC2,6),BAL(INC2,3),BAL(INC2,1),
     1                   BAL(INC2,5)
 1360 FORMAT(' ',70('-')/' ','FEED',5X,5(F6.2,4X),' N/A')
 1310 CONTINUE
      WRITE(6,1370)ROUGH(INC2,5)
 1370 FORMAT(' ',70('-')/' ',40X,'MEASURED: ',F5.2/' ',40X,20('-'))
C
C COMPONENT RECOVERIES FOR MODELLING
C
      WRITE(6,1400)
 1400 FORMAT('0','SLURRY COMPONENT RECOVERIES (MODELLING):'/' ',
     1       40('-')/' ','FLOAT',5X,'ORGANICS',2X,'ASH',7X,'WATER'/' ',
     2       'TIME'/' ',40('-'))
      DO 1410 I=1,INC
      WRITE(6,1420)TIME(I),(RECOV(I,J),J=1,3)
 1420 FORMAT(' ',4(F5.2,5X))
 1410 CONTINUE
C
C SIMPLE LINEAR CORRELATION RESULTS
C
      WRITE(6,1430)
 1430 FORMAT(' ',40('-')/'0','SIMPLE LINEAR CORRELATIONS:',
     1       /' ',27('-')/'-','INDEP.',4X,'DEP.',6X,'SLOPE',5X,
     2       'INTERCEPT',2X,'F(CALC.)',4X,'R-SQRD'/' ',
     3       2('VARIABLE',2X)/' ',80('-'))
      WRITE(6,1440)(REG(1,J),J=1,4)
      WRITE(6,1450)(REG(2,J),J=1,4)
      WRITE(6,1460)(REG(3,J),J=1,4)
 1440 FORMAT(' ','ASH       ORGANICS  ',4(F8.3,2X))
 1450 FORMAT(' ','WATER     ORGANICS  ',4(F8.3,2X))
 1460 FORMAT(' ','WATER     ASH       ',4(F8.3,2X)/' ',80('-'))
C
C-----------------------------------------------------
```

```
      C
      C   PARAMETERIZATION OF THE SIMPLE KINETIC MODEL
      C   USING NON-LINEAR REGRESSION
      C
      C-------------------------------------------------------
      C
           WRITE(6,1999)
      1999 FORMAT('-',20X,'SIMPLE FIRST ORDER MODEL RESULTS'/' ',
          1        27X,'R=RMAX(1-EXP(-KT))'/' ',20X,32('*'))
      C
      C  COMPUTE PARAMETERS FOR EACH COMPONENT
      C
           DO 2000 IC=1,3
      C
      C  ESTIMATE INITIAL VALUES
      C
           P2(1)=RECOV(INC,IC)+0.5
           P2(2)=-ALOG(1.-RECOV(2,IC)/P2(1))/TIME(2)
           ICYC1=0
           RSS=0.
      C
      C CONSTRUCT THE INITIAL Y MATRIX
      C
           DO 2010 I=1,INC
           Y(I)=RECOV(I,IC)-P2(1)*(1.-EXP(-P2(2)*TIME(I)))
      2010 CONTINUE
      C
      C BEGIN THE ITERATIVE REGRESSION SOLUTION BY FORMING X AND X'
      C
      2015 ICYC1=ICYC1+1
           DO 2020 I=1,INC
           X(I,1)=1.-EXP(-P2(2)*TIME(I))
           XT(1,I)=X(I,1)
           X(I,2)=TIME(I)*P2(1)*EXP(-P2(2)*TIME(I))
           XT(2,I)=X(I,2)
      2020 CONTINUE
      C
      C  COMPUTE X'X
      C
           CALL VMULFF(XT,X,2,INC,2,2,10,XTX,2,IER)
      C
      C  COMPUTE X'Y
      C
           CALL VMULFF(XT,Y,2,INC,1,2,10,XTY,2,IER)
      C
      C  COMPUTE (X'X) INVERSE
      C
           IDUM=0
           CALL LINV2F(XTX,2,2,XTXINV,IDUM,WORK,IER)
      C
      C  COMPUTE THE PARAMETER ADJUSTMENT VECTOR
      C
           CALL VMULFF(XTXINV,XTY,2,2,1,2,2,DELP,2,IER)
      C
      C UPDATE THE COEFFICIENTS
      C
           P2(1)=P2(1)+DELP(1)
           P2(2)=P2(2)+DELP(2)
      C
      C  CHECK FOR CONVERGENCE

           RSSP=RSS
           RSS=0.
           DO 2040 I=1,INC
           Y(I)=RECOV(I,IC)-P2(1)*(1.-EXP(-P2(2)*TIME(I)))
           RSS=RSS+Y(I)**2
      2040 CONTINUE
           IF(ICYC1.GT.30)GOTO 2050
           IF(ABS((RSS-RSSP)/RSS).GT.0.0001)GOTO 2015
      2050 IF(IC.EQ.1)WRITE(6,2060)
           IF(IC.EQ.2)WRITE(6,2070)
           IF(IC.EQ.3)WRITE(6,2080)
      2060 FORMAT('-','RESULTS FOR THE ORGANICS COMPONENT:'/' ',35('*'))
      2070 FORMAT('-','RESULTS FOR THE ASH COMPONENT:'/' ',30('*'))
      2080 FORMAT('-','RESULTS FOR THE WATER COMPONENT:'/' ',32('*'))
           DF=RINC-2.
           S=RSS/DF
           SE(1)=(XTXINV(1,1)*S)**0.5
           SE(2)=(XTXINV(2,2)*S)**0.5
           RR=XTXINV(1,2)/((XTXINV(1,1)**.5)*(XTXINV(2,2)**.5))
           WRITE(6,2090)
      2090 FORMAT('0','PARAMETER ESTIMATE  STD. ERROR'/' ',30('-'))
           WRITE(6,2100)P2(1),SE(1)
      2100 FORMAT(' ','RMAX (%)',2X,F6.2,4X,F6.3)
           WRITE(6,2110)P2(2),SE(2)
      2110 FORMAT(' ','K (1/MIN)',1X,F6.3,4X,F6.3/' ',30('-'))
           WRITE(6,2115)ICYC1
      2115 FORMAT('0','NUMBER OF ITERATIONS WAS ',I2)
           IF(ICYC1.GT.30)WRITE(6,2117)
      2117 FORMAT('+','  ***WARNING: LIMIT EXCEEDED WITHOUT CONVERGENCE')
           WRITE(6,2120)RSS,S,DF
      2120 FORMAT(' ','RESIDUAL SS=',F7.1,5X,'RESIDUAL MEAN SS=',F6.2,
          1        5X,'WITH ',F4.1,' DEGREES OF FREEDOM')
           WRITE(6,2130)RR
      2130 FORMAT(' ','PARAMETER CORRELATION COEFFICIENT: ',F6.3)
           WRITE(6,2140)
      2140 FORMAT('0','MODEL PREDICTIONS:'/' ',17('-')/' ','TIME',6X,
          1        'OBS. REC.',1X,'EST. REC.',1X,'RESIDUAL'/' ',40('-'))
           DO 2150 I=1,INC
           PRED=P2(1)*(1.-EXP(-P2(2)*TIME(I)))
           RES=RECOV(I,IC)-PRED
           WRITE(6,2160)TIME(I),RECOV(I,IC),PRED,RES
      2160 FORMAT(' ',4(F8.2,4X))
      2150 CONTINUE
           WRITE(6,2170)
      2170 FORMAT(' ',40('-'))
      2000 CONTINUE
      C
      C-------------------------------------------------------
      C
      C   PARAMETERIZATION OF THE COMPOUND KINETIC MODEL
      C   USING NON-LINEAR REGRESSION
      C
      C-------------------------------------------------------
      C
           WRITE(6,2999)
      2999 FORMAT('-',20X,'COMPOUND FIRST ORDER MODEL RESULTS'/' ',
          1        15X,'R=(100-PHI)(1-EXP(-KF*T))+PHI(1-EXP(-KS*T))',
          2        /' ',15X,44('*'))
      C
      C  COMPUTE PARAMETERS FOR EACH COMPONENT
```

```
C
      IFLAG(1)=0
      IFLAG(2)=0
      IFLAG(3)=0
      DO 3000 IC=1,3
C
C  ESTIMATE INITIAL VALUES
C
      INCD=INC-1
      P3(3)=ALOG((100.-RECOV(INCD,IC))/(100.-RECOV(INC,IC)))/
     1       (TIME(INC)-TIME(INCD))
      P3(1)=EXP(ALOG(100.-RECOV(INCD,IC))+P3(3)*TIME(INCD))
      IF(P3(1).GT.99.9)P3(1)=99.9
      DUM=(1.-(RECOV(2,IC)-P3(1)*(1.-EXP(-P3(3)*TIME(2))))
     1       /(100.-P3(1)))
      IF(DUM.LT.0.)GOTO 3005
      P3(2)=-ALOG(DUM)/TIME(2)
      GOTO 3006
 3005 P3(2)=1.25
 3006 ICYC1=0
      RSS=0.
C
C CONSTRUCT THE INITIAL W MATRIX
C
      DO 3010 I=1,INC
      W(I)=RECOV(I,IC)-(100.-P3(1))*(1.-EXP(-P3(2)*TIME(I)))-
     1      P3(1)*(1.-EXP(-P3(3)*TIME(I)))
 3010 CONTINUE
C
C BEGIN THE ITERATIVE REGRESSION SOLUTION BY FORMING Z AND Z'
C
 3015 ICYC1=ICYC1+1
      DO 3020 I=1,INC
      Z(I,1)=EXP(-P3(2)*TIME(I))-EXP(-P3(3)*TIME(I))
      ZT(1,I)=Z(I,1)
      Z(I,2)=(100.-P3(1))*TIME(I)*EXP(-P3(2)*TIME(I))
      ZT(2,I)=Z(I,2)
      Z(I,3)=P3(1)*TIME(I)*EXP(-P3(3)*TIME(I))
      ZT(3,I)=Z(I,3)
 3020 CONTINUE
C
C  COMPUTE Z'Z
C
      CALL VMULFF(ZT,Z,3,INC,3,3,10,ZTZ,3,IER)
C
C  COMPUTE Z'W
C
      CALL VMULFF(ZT,W,3,INC,1,3,10,ZTW,3,IER)
C
C  COMPUTE (Z'Z) INVERSE
C
      IDUM=0
      CALL LINV2F(ZTZ,3,3,ZTZINV,IDUM,WORK,IER)
C
C  COMPUTE THE PARAMETER ADJUSTMENT VECTOR
C
      CALL VMULFF(ZTZINV,ZTW,3,3,1,3,3,DELP3,3,IER)
C
C UPDATE THE COEFFICIENTS
C


      P3(1)=P3(1)+DELP3(1)
      P3(2)=P3(2)+DELP3(2)
      P3(3)=P3(3)+DELP3(3)
C
C  CHECK FOR CONSTRAINTS
C
      DF=RINC-3.
      DO 3035 I=1,3
      IF(P3(I).GE.PMIN(I).AND.P3(I).LE.PMAX(I))GOTO 3037
      IFLAG(I)=1
      IF(P3(I).LT.PMIN(I))P3(I)=PMIN(I)
      IF(P3(I).GT.PMAX(I))P3(I)=PMAX(I)
      GOTO 3038
 3037 IFLAG(I)=0
 3038 DF=DF+IFLAG(I)
 3035 CONTINUE
C
C  CHECK FOR CONVERGENCE
C
      RSSP=RSS
      RSS=0.
      DO 3040 I=1,INC
      W(I)=RECOV(I,IC)-(100.-P3(1))*(1.-EXP(-P3(2)*TIME(I)))-
     1      P3(1)*(1.-EXP(-P3(3)*TIME(I)))
      RSS=RSS+W(I)**2
 3040 CONTINUE
      IF(ICYC1.GT.30)GOTO 3050
      IF(ABS((RSS-RSSP)/RSS).GT.0.0001)GOTO 3015
 3050 IF(IC.EQ.1)WRITE(6,3060)
      IF(IC.EQ.2)WRITE(6,3070)
      IF(IC.EQ.3)WRITE(6,3080)
 3060 FORMAT('-','RESULTS FOR THE ORGANICS COMPONENT:'/' ',35('*'))
 3070 FORMAT('-','RESULTS FOR THE ASH COMPONENT:'/' ',30('*'))
 3080 FORMAT('-','RESULTS FOR THE WATER COMPONENT:'/' ',32('*'))
      S=RSS/DF
      SE3(1)=(ZTZINV(1,1)*S)**0.5
      SE3(2)=(ZTZINV(2,2)*S)**0.5
      SE3(3)=(ZTZINV(3,3)*S)**0.5
      RR12=ZTZINV(1,2)/((ZTZINV(1,1)**.5)*(ZTZINV(2,2)**.5))
      RR13=ZTZINV(1,3)/((ZTZINV(1,1)**.5)*(ZTZINV(3,3)**.5))
      RR23=ZTZINV(2,3)/((ZTZINV(2,2)**.5)*(ZTZINV(3,3)**.5))
      WRITE(6,3090)
 3090 FORMAT('0','PARAMETER ESTIMATE  STD. ERR. CONSTRAINED',
     1        /' ',41('-'))
      WRITE(6,3100)P3(1),SE3(1),IFLAG(1)
 3100 FORMAT(' ','PHI   (%)',2X,F6.2,4X,F6.3,4X,I2)
      WRITE(6,3105)P3(2),SE3(2),IFLAG(2)
 3105 FORMAT(' ','KF(1/MIN)',1X,F6.3,4X,F6.3,4X,I2)
      WRITE(6,3110)P3(3),SE3(3),IFLAG(3)
 3110 FORMAT(' ','KS(1/MIN)',1X,F6.3,4X,F6.3,4X,I2/' ',41('-'))
      WRITE(6,3115)ICYC1
 3115 FORMAT('0','NUMBER OF ITERATIONS WAS ',I2)
      IF(ICYC1.GT.30)WRITE(6,3117)
 3117 FORMAT('+','  ***WARNING: LIMIT EXCEEDED WITHOUT CONVERGENCE')
      WRITE(6,3120)RSS,S,DF
 3120 FORMAT(' ','RESIDUAL SS=',F7.1,5X,'RESIDUAL MEAN SS=',F6.2,
     1         5X,'WITH ',F4.1,' DEGREES OF FREEDOM')
      WRITE(6,3130)RR12,RR13,RR23
 3130 FORMAT(' ','PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)=',
     1         F6.3,5X,'R(PHI-KS)=',F6.3,5X,'R(KF-KS)=',F6.3)
```

```
      WRITE(6,3140)
 3140 FORMAT('0','MODEL PREDICTIONS:'/' ',17('-')/' ','TIME',8X,
     1       'OBS. REC.',1X,'EST. REC.',1X,'RESIDUAL'/' ',40('-'))
      DO 3150 I=1,INC
      PRED=(100.-P3(1))*(1.-EXP(-P3(2)*TIME(I)))+P3(1)*
     1     (1.-EXP(-P3(3)*TIME(I)))
      RES=RECOV(I,IC)-PRED
      WRITE(6,3160)TIME(I),RECOV(I,IC),PRED,RES
 3160 FORMAT(' ',4(F5.2,4X))
 3150 CONTINUE
      WRITE(6,3170)
 3170 FORMAT(' ',40('-'))
 3000 CONTINUE
      STOP
      END
End of file
```

9. APPENDIX III

Three Examples Of The Outputs From The Data Processing Programs

```
                    ******************************
                    *  BATCH FLOTATION STUDIES   *
                    *  ON GREGG RIVER RESOURCES  *
                    *         FINE COAL          *
                    ******************************


IDENTIFICATION: BLOCK#  4     TEST#  1     DATE: FEB. 7, 1983            TYPE: SCREENING TESTS
---------------


EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED     ACTUAL     UNITS
           LEVEL     LEVEL
-----------------------------------------
AIR         -1       3.0        L/MIN.
COLLECT.    -1       0.2        L/TONNE
FROTHER     -1       0.15       L/TONNE
CONDIT.     -1       1.0        MINUTES
% SOLIDS    -1       3.0        %
RPM          1       1250.0
PH           1       8.8
-----------------------------------------

MISCELLANEOUS DATA: TORQUE(G)= 110.0     RESERVOIR WATER ADDED(G)= 282.0
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %     WT. %     CUM.      CUM.       CUM
INCREMENT SOLIDS %  ASH       SOLIDS    RECOVERED WT. %      WT. %
(MIN.)                                  % SOLIDS  ASH        SOLIDS
-----------------------------------------------------------------------
 0.50     22.49      4.89     23.04     22.49      4.89      23.04
 1.00     11.26      4.79     18.58     33.75      4.72      21.33
 2.00      7.80      5.06     16.15     41.55      4.78      20.12
 4.00      4.56      5.21      6.45     46.11      4.83      18.64
 8.00      3.80     10.06      2.50     49.91      5.22      11.63
-----------------------------------------------------------------------
TAILINGS  50.09     17.78      1.70     N/A        N/A       N/A
-----------------------------------------------------------------------
FEED     100.00     11.64      2.98    100.00     11.64      N/A
-----------------------------------------------------------------------
                                        MEASURED: 11.76
                                        -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
-----------------------------------------
FLOAT     ORGANICS  ASH       WATER
TIME
-----------------------------------------
 0.50     24.25      9.06      2.29
 1.00     36.39     13.59      3.80
 2.00     44.77     17.08      5.04
 4.00     49.66     19.12      7.06
 8.00     53.53     22.41     11.58
-----------------------------------------




SIMPLE LINEAR CORRELATIONS:
---------------------------


INDEP.    DEP.      SLOPE     INTERCEPT  F(CALC.)    R-SQRD
VARIABLE  VARIABLE
-----------------------------------------------------------
ASH        ORGANICS   0.435    -1.884   168.266     0.982
WATER      ORGANICS   0.271    -5.363    10.288     0.774
WATER      ASH        0.655    -4.707    20.457     0.872
-----------------------------------------------------------

                    SIMPLE FIRST ORDER MODEL RESULTS
                         R=RMAX(1-EXP(-KT))
                    ******************************

RESULTS FOR THE ORGANICS COMPONENT:
***********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)   51.28     1.349
K (1/MIN)  1.210     0.111
------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=   11.4     RESIDUAL MEAN SS=  3.81     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.835

MODEL PREDICTIONS:
------------------
TIME      OBS. REC. EST. REC. RESIDUAL
---------------------------------------
  0.50     24.25     23.28     0.97
  1.00     36.39     35.99     0.40
  2.00     44.77     46.72    -1.95
  4.00     49.66     50.87    -1.21
  8.00     53.53     51.27     2.25
---------------------------------------

RESULTS FOR THE ASH COMPONENT:
******************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)   20.78     1.041
K (1/MIN)  1.027     0.170
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=    6.1     RESIDUAL MEAN SS=  2.03     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.857

MODEL PREDICTIONS:
------------------
TIME      OBS. REC. EST. REC. RESIDUAL
---------------------------------------
```

```
  0.50       9.06       8.34       0.72
  1.00      13.69      13.33       0.36
  2.00      17.08      18.10      -1.02
  4.00      19.12      20.42      -1.30
  8.00      22.41      20.76       1.65
-----------------------------------------

RESULTS FOR THE WATER COMPONENT:
********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    13.00      2.319
K (1/MIN)  0.245      0.088
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=     2.9      RESIDUAL MEAN SS=  0.96      WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.931

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50       2.29       1.50      -0.80
  1.00       3.80       2.82       0.98
  2.00       5.04       5.03       0.01
  4.00       7.05       8.12      -1.06
  8.00      11.58      11.18       0.41
-----------------------------------------

                    COMPOUND FIRST ORDER MODEL RESULTS
                R=(100-PHI)(1-EXP(-KF*T))+PHI(1-EXP(-KS*T))
                *******************************************

RESULTS FOR THE ORGANICS COMPONENT:
***********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI  (%)    54.91      0.635      0
KF(1/MIN)  1.498      0.043      0
KS(1/MIN)  0.021      0.002      0
-----------------------------------------

NUMBER OF ITERATIONS WAS  2
RESIDUAL SS=     0.2      RESIDUAL MEAN SS=  0.12      WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.845      R(PHI-KS)= 0.919      R(KF-KS)= 0.733

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50      24.26      24.35      -0.09
  1.00      36.39      36.16       0.23
  2.00      44.77      45.10      -0.33
  4.00      49.66      49.41       0.25



  8.00      53.53      53.60      -0.07
-----------------------------------------

RESULTS FOR THE ASH COMPONENT:
******************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI  (%)    83.92      0.276      0
KF(1/MIN)  1.578      0.059      0
KS(1/MIN)  0.010      0.001      0
-----------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=     0.1      RESIDUAL MEAN SS=  0.03      WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.832      R(PHI-KS)= 0.916      R(KF-KS)= 0.721

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50       9.06       9.19      -0.13
  1.00      13.69      13.58       0.12
  2.00      17.08      17.01       0.07
  4.00      19.12      19.25      -0.13
  8.00      22.41      22.36       0.04
-----------------------------------------

RESULTS FOR THE WATER COMPONENT:
********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI  (%)    97.22      0.298      0
KF(1/MIN)  2.204      0.645      0
KS(1/MIN)  0.012      0.001      0
-----------------------------------------

NUMBER OF ITERATIONS WAS  6
RESIDUAL SS=     0.1      RESIDUAL MEAN SS=  0.05      WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.786      R(PHI-KS)= 0.887      R(KF-KS)= 0.657

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50       2.29       2.43      -0.13
  1.00       3.80       3.61       0.19
  2.00       5.04       5.00       0.03
  4.00       7.05       7.24      -0.19
  8.00      11.58      11.51       0.07
-----------------------------------------
```

```
                   *******************************
                   *    SIZE FRACTION  STUDIES    *
                   *  ON GREGG RIVER RESOURCES    *
                   *          FINE COAL           *
                   *******************************


IDENTIFICATION:   TEST#   1          DATE: 1   MONTH: 4   YEAR:1983
---------------


SIZE FREQUENCY PER MESH AND ASH DATA:
-----------------------------------
             +200 MESH           -200/+325          -325 MESH
    TIME     WT%      % ASH     WT%      % ASH     WT%      % ASH
---------------------------------------------------------------------
   30 SEC   11.13      4.23    34.76      4.45    36.15      5.51
   1  MIN    5.89      4.26    12.91      4.32    14.56      5.46
   2  MIN    3.32      4.15    11.92      4.29     4.80      5.87
   4  MIN    2.04      4.94     3.48      5.49     4.73      5.68
   8  MIN    2.87      8.32     3.79      9.57     3.93      8.84
   TAIL     74.75     13.15    33.15     23.97    35.83     24.87
---------------------------------------------------------------------


SIZE FREQUENCY PER INCREMENT:
---------------------------
             +200 MESH  -200/+325  -325 MESH
-------------------------------------------
   30 SEC   15.11        23.19       61.70
   1  MIN   19.28        20.78       59.94
   2  MIN   21.84        38.48       39.68
   4  MIN   21.07        17.61       61.32
   8  MIN   29.65        19.24       51.10
   TAIL     54.93        11.97       33.10
-------------------------------------------
   FEED     36.38        17.88       45.74
-------------------------------------------


RECOVERY DATA:
-------------
             +200 MESH             -200/+325          -325 MESH
    TIME     %ASH      %ORG       %ASH      %ORG      %ASH      %ORG      WATER
-------------------------------------------------------------------------------
   30 SEC     4.26     11.99     13.92     37.37     15.88     39.05      2.29
   1  MIN     6.53     18.32     18.94     51.26     22.24     54.76      3.80
   2  MIN     7.76     21.90     23.54     64.10     24.49     59.95      5.04
   4  MIN     8.69     24.09     25.26     67.79     26.53     65.05      7.05
   8  MIN    11.11     27.01     28.52     71.65     28.72     69.10     11.58
-------------------------------------------------------------------------------


BACK CALCULATION OF FEED ASSAY:
------------------------------
CALCULATED %ASH IN FEED: 11.74
MEASURED % ASH IN FEED:  11.76
----------------------------------------




SIMPLE LINEAR CORRELATIONS:
--------------------------


INDEP        DEP            SLOPE  INTERCEPT  F(CALC.)    R-SQRD
VARIABLE     VARIABLE
-----------------------------------------------------------------
WATER      +200 ASH         1.369    -4.881     42.363     0.934
WATER -200/+325 ASH         0.577    -6.754     15.290     0.836
WATER      -325 ASH         0.628    -8.985     14.270     0.828
-----------------------------------------------------------------
WATER      +200 ORG         0.580    -5.809     13.017     0.813
WATER -200/+325 ORG         0.216    -6.782      7.886     0.724
WATER      -325 ORG         0.285    -9.033      8.850     0.742
-----------------------------------------------------------------

                        SIMPLE FIRST ORDER MODEL RESULTS
                              R=RMAX(1-EXP(-KT))
                        ********************************


RESULTS FOR THE +200 MESH ASH COMP:
**********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)     9.92     0.787
K (1/MIN)  0.966      0.246
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=     3.3      RESIDUAL MEAN SS=  1.11     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.888

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       4.26       3.80       0.46
  1.00       6.53       6.14       0.39
  2.00       7.76       8.48      -0.71
  4.00       8.69       9.71      -1.02
  8.00      11.11       9.92       1.19
----------------------------------------


RESULTS FOR THE -200/-325 ASH COMP:
*******************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    28.58      1.095
K (1/MIN)   1.306      0.194
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=     7.9      RESIDUAL MEAN SS=  2.63     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.628
```

```
MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       13.92     12.75      1.17
  1.00       18.94     19.38     -0.44
  2.00       23.54     24.63     -1.09
  4.00       25.25     26.43     -1.18
  8.00       28.52     26.58      1.94
----------------------------------------


RESULTS FOR THE -325 MESH ASH COMP:
**********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    27.48      1.145
K (1/MIN)   1.631      0.268
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=    9.8      RESIDUAL MEAN SS=  3.26      WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.600

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       15.89     15.32      0.57
  1.00       22.24     22.10      0.14
  2.00       24.49     26.43     -1.94
  4.00       26.63     27.44     -0.81
  8.00       29.72     27.48      2.24
----------------------------------------


RESULTS FOR THE +200 MESH ORG COMP:
**********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    25.34      0.959
K (1/MIN)   1.221      0.162
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=    5.8      RESIDUAL MEAN SS=  1.94      WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.634

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       11.99     11.58      0.41
  1.00       18.32     17.86      0.46
  2.00       21.90     23.14     -1.23
  4.00       24.09     25.15     -1.06
  8.00       27.01     25.34      1.67
----------------------------------------



RESULTS FOR THE -200/+325 ORG COMP:
**********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    69.25      1.461
K (1/MIN)   1.430      0.112
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=   14.6      RESIDUAL MEAN SS=  4.88      WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.615

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       37.37     35.37      2.00
  1.00       51.26     52.67     -1.41
  2.00       64.10     65.29     -1.19
  4.00       67.79     69.02     -1.23
  8.00       71.65     69.25      2.39
----------------------------------------

RESULTS FOR THE -325 MESH ORG COMP:
**********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    65.68      1.685
K (1/MIN)   1.763      0.204
------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=   26.9      RESIDUAL MEAN SS=  8.96      WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.591

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       39.05     38.35      0.70
  1.00       54.78     54.31      0.47
  2.00       59.95     63.71     -3.76
  4.00       65.05     65.62     -0.57
  8.00       69.10     65.68      3.42
----------------------------------------

                    COMPOUND FIRST ORDER MODEL RESULTS
               R=(100-PHI)(1-EXP(-KF*T))+PHI(1-EXP(-KS*T))
               *******************************************


RESULTS FOR THE +200 MESH ASH COMP:
**********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
```

```
PHI  (%)    93.24      0.388      0
KF(1/MIN)   1.816      0.273      0
KS(1/MIN)   0.005      0.001      0
------------------------------------------

NUMBER OF ITERATIONS WAS  4
RESIDUAL SS=    0.1     RESIDUAL MEAN SS=  0.07     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.802     R(PHI-KS)= 0.901     R(KF-KS)= 0.683

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50       4.26      4.44    -0.18
  1.00       6.53      6.31     0.22
  2.00       7.78      7.70     0.08
  4.00       8.69      8.92    -0.23
  8.00      11.11     11.03     0.08
-----------------------------------------


RESULTS FOR THE -200/-325 ASH COMP:
***************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
------------------------------------------
PHI  (%)    77.83      0.880      0
KF(1/MIN)   1.816      0.132      0
KS(1/MIN)   0.011      0.002      0
------------------------------------------

NUMBER OF ITERATIONS WAS  2
RESIDUAL SS=    0.4     RESIDUAL MEAN SS=  0.20     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.813     R(PHI-KS)= 0.904     R(KF-KS)= 0.693

MODEL PREDICTIONS
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50      13.92     13.64     0.28
  1.00      18.94     19.39    -0.45
  2.00      23.54     23.22     0.32
  4.00      25.26     25.38    -0.13
  8.00      28.52     28.49     0.02
-----------------------------------------


RESULTS FOR THE -325 MESH ASH COMP:
******************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
------------------------------------------
PHI  (%)    76.57      0.611      0
KF(1/MIN)   2.237      0.181      0
KS(1/MIN)   0.011      0.002      0
------------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=    0.4     RESIDUAL MEAN SS=  0.21     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.783     R(PHI-KS)= 0.886     R(KF-KS)= 0.654



MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50      15.89     16.18    -0.29
  1.00      22.24     21.74     0.50
  2.00      24.49     24.78    -0.29
  4.00      26.63     26.63     0.01
  8.00      29.72     29.70     0.03
-----------------------------------------


RESULTS FOR THE +200 MESH ORG COMP:
********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
------------------------------------------
PHI  (%)    78.84      0.604      0
KF(1/MIN)   1.636      0.103      0
KS(1/MIN)   0.009      0.001      0
------------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=    0.3     RESIDUAL MEAN SS=  0.14     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.827     R(PHI-KS)= 0.913     R(KF-KS)= 0.714

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50      11.99     12.30    -0.31
  1.00      18.32     17.93     0.39
  2.00      21.90     21.99    -0.09
  4.00      24.09     24.19    -0.10
  8.00      27.01     26.97     0.04
-----------------------------------------


RESULTS FOR THE -200/+325 ORG COMP:
***************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
------------------------------------------
PHI  (%)    36.46      2.193      0
KF(1/MIN)   1.660      0.122      0
KS(1/MIN)   0.032      0.011      0
------------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=    3.1     RESIDUAL MEAN SS=  1.54     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.837     R(PHI-KS)= 0.906     R(KF-KS)= 0.713

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC. EST. REC. RESIDUAL
-----------------------------------------
  0.50      37.37     36.41     0.96
  1.00      51.26     52.60    -1.33
  2.00      64.10     63.48     0.62
  4.00      67.79     67.80    -0.00
  8.00      71.65      71.70      -0.05
---------------------------------------

RESULTS FOR THE -325 MESH ORG COMP:
**********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI. (%)   41.04     1.917     0
KF(1/MIN)  2.180     0.178     0
KS(1/MIN)  0.036     0.009     0
-----------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=    3.3     RESIDUAL MEAN SS=  1.64     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.803     R(PHI-KS)= 0.883     R(KF-KS)= 0.683

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
---------------------------------------
  0.50      39.05      39.67      -0.62
  1.00      54.78      53.61       1.16
  2.00      59.95      61.03      -1.08
  4.00      65.05      64.46       0.59
  8.00      69.10      69.24      -0.14
---------------------------------------
```

```
                    ********************************
                    *  BATCH FLOTATION STUDIES'    *
                    *  ON GREGG RIVER RESOURCES    *
                    *          FINE COAL           *
                    ********************************


IDENTIFICATION: BLOCK#  7     TEST#  1    DATE:   MAY  31 1983          TYPE:   MODELLING TESTS
---------------

EXPERIMENTAL CONDITIONS:
------------------------
FACTOR     CODED      ACTUAL     UNITS
           LEVEL      LEVEL
---------------------------------------
AIR          -1       2.0        L/MIN.
COLLECT.     -1       0.296      L/TONNE
FROTHER      -1       0.1244     L/TONNE
% SOLIDS     -1       3.0        %
CONDIT        0       1.0        MINUTES
RPM           0       850.0
PH            0       7.8
---------------------------------------

MISCELLANEOUS DATA: TORQUE(G)=  71.0     RESERVOIR WATER ADDED(G)= 148.5
------------------

EXPERIMENTAL RESULTS:
---------------------
FLOAT     RECOVERED WT. %      WT. %      CUM.       CUM.       CUM.
INCREMENT SOLIDS %  ASH        SOLIDS     RECOVERED  WT. %      WT. %
(MIN.)                                    % SOLIDS   ASH        SOLIDS
----------------------------------------------------------------------
  0.50      11.01      5.03      19.27     11.01      5.03      19.27
  1.00       5.74      5.08      15.76     16.75      5.05      17.90
  2.00       4.53      4.87       9.59     21.28      5.01      15.11
  4.00       4.30      5.06       6.82     25.58      5.02      12.56
  8.00       6.48      5.61       7.07     32.05      5.14      10.85
----------------------------------------------------------------------
TAILINGS  67.95       15.59       2.42     N/A        N/A        N/A
----------------------------------------------------------------------
FEED     100.00       12.09       3.22    100.00     12.09       N/A
----------------------------------------------------------------------
                                          MEASURED: 11.93
                                          -------------------

SLURRY COMPONENT RECOVERIES (MODELLING):
----------------------------------------
FLOAT      ORGANICS  ASH        WATER
TIME
----------------------------------------
  0.50      11.89      4.56      1.53
  1.00      18.09      7.00      2.55
  2.00      22.99      8.82      3.87
  4.00      27.63     10.82      5.93
  8.00      34.59     13.63      8.76
----------------------------------------
```

```
SIMPLE LINEAR CORRELATIONS:
---------------------------

INDEP.    DEP.        SLOPE      INTERCEPT  F(CALC.)    R-SQRD
VARIABLE  VARIABLE
----------------------------------------------------------------
ASH       ORGANICS     0.396     -0.185   3214.221      0.999
WATER     ORGANICS     0.325     -2.931     91.174      0.968
WATER     ASH          0.822     -2.792    115.163      0.975
----------------------------------------------------------------

                    SIMPLE FIRST ORDER MODEL RESULTS
                          R=RMAX(1-EXP(-KT))
                    ********************************

RESULTS FOR THE ORGANICS COMPONENT:
***********************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    32.01      2.332
K (1/MIN)  0.742       0.160
------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=    23.3      RESIDUAL MEAN SS=  7.76     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.708

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC  EST. REC. RESIDUAL
---------------------------------------
  0.50      11.89       9.93      1.97
  1.00      18.09      16.77      1.32
  2.00      22.99      24.75     -1.76
  4.00      27.63      30.37     -2.73
  8.00      34.58      31.92      2.66
---------------------------------------

RESULTS FOR THE ASH COMPONENT
*****************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)    12.56      1.016
K (1/MIN)  0.710       0.167
------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=     4.2      RESIDUAL MEAN SS=  1.41     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.716

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC  EST. REC. RESIDUAL
---------------------------------------



  0.50       4.58       3.75      0.83
  1.00       7.00       6.38      0.62
  2.00       8.82       9.52     -0.70
  4.00      10.62      11.83     -1.21
  8.00      13.63      12.52      1.11
---------------------------------------

RESULTS FOR THE WATER COMPONENT
*******************************

PARAMETER ESTIMATE  STD. ERROR
------------------------------
RMAX (%)     9.85      0.815
K (1/MIN)  0.257       0.043
------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=     0.4      RESIDUAL MEAN SS=  0.14     WITH  3.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENT: -0.823

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC  EST. REC. RESIDUAL
---------------------------------------
  0.50       1.53       1.19      0.34
  1.00       2.55       2.23      0.32
  2.00       3.97       3.96      0.01
  4.00.      5.93       6.33     -0.40
  8.00       8.76       8.60      0.16
---------------------------------------

                  COMPOUND FIRST ORDER MODEL RESULTS
              R=(100-PHI)(1-EXP(-KF*T))+PHI(1-EXP(-KS*T))
              *******************************************

RESULTS FOR THE ORGANICS COMPONENT:
***********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI  (%)    80.04      0.273      0
KF(1/MIN)   1.603      0.046      0
KS(1/MIN)   0.025      0.001      0
-----------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=     0.0      RESIDUAL MEAN SS=  0.02     WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.838     R(PHI-KS)= 0.812     R(KF-KS)= 0.720

MODEL PREDICTIONS:
-----------------
TIME       OBS. REC  EST. REC. RESIDUAL
---------------------------------------
  0.50      11.89      12.01     -0.11
  1.00      18.09      17.93      0.16
  2.00      22.99      23.08     -0.09
  4.00      27.63      27.61      0.03
  8.00      34.59      34.59      -0.00
----------------------------------------

RESULTS FOR THE ASH COMPONENT:
******************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI  (%)   82.42      0.141      0
KF(1/MIN)  1.853      0.069      0
KS(1/MIN)  0.008      0.000      0
-----------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=     0.0      RESIDUAL MEAN SS=  0.01      WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.825      R(PHI-KS)= 0.913      R(KF-KS)= 0.712

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       4.58      4.65      -0.07
  1.00       7.00      6.91       0.09
  2.00       8.82      8.85      -0.03
  4.00      10.62     10.64      -0.02
  8.00      13.63     13.62       0.01
----------------------------------------


RESULTS FOR THE WATER COMPONENT:
********************************

PARAMETER ESTIMATE  STD. ERR. CONSTRAINED
-----------------------------------------
PHI  (%)   96.92      0.176      0
KF(1/MIN)  0.901      0.080      0
KS(1/MIN)  0.008      0.000      0
-----------------------------------------

NUMBER OF ITERATIONS WAS  3
RESIDUAL SS=     0.0      RESIDUAL MEAN SS=  0.00      WITH  2.0 DEGREES OF FREEDOM
PARAMETER CORRELATION COEFFICIENTS: R(PHI-KF)= 0.911      R(PHI-KS)= 0.982      R(KF-KS)= 0.861

MODEL PREDICTIONS:
------------------
TIME       OBS. REC. EST. REC. RESIDUAL
----------------------------------------
  0.50       1.53      1.48       0.05
  1.00       2.55      2.56      -0.01
  2.00       3.97      4.03      -0.05
  4.00       5.93      5.89       0.04
  8.00       8.76      8.77      -0.01
----------------------------------------
```

10. APPENDIX IV

Computer Program For Factorial Design Analysis
Using Modified Stepwise Linear Regression In
HP-9825-A Language

```
"FULL 2^N FACTORIAL DESIGN ANALYSIS":
"PROGRAM WRITTEN FOR DATA REDUCTION IN THE":
"GREGG RIVER PROJECT":
"AUTHOR:  B.C. FLINTOFF":
"VERSION:  #1, JUNE 1983":
"*****************************************************":
"     ":
fxd 0
ent "N", N
2^N--R
dim D[R,R],B$[R,10],N[N],C[R,2],R[R],O[R,5]
"     ":
"CALCULATE THE DESIGN MATRIX ENTRIES IN CODED LEVELS":
"     ":
for I=1 to R
1--D[I,1]
next I
"I"--B$[1]
for J=2 to N+1
2^(J-2)--P; 1--M
str(J-1)--B$[J]
for L=1 to R by P
-M--M
for K=L to L+P-1
M--D[K,J]
next K
next L
next J
N+2--C
for Z=2 to N
for I=1 to Z
I--N[I]
next I
"o":sfg 1;0--S;for L=1 to R
1--M;0--T
for K=1 to Z
M*D[L,N[K]+1]--M
if flg1;T+N[K]*10^(Z-K)--T
next K
if flg1;cfg 1;str(T)--B$[C]
M--D[L,C]
S+M--S
next L
if S#0;dsp "STOP ON NON-ZERO COLUMN", stp
Z--I;C+1--C
"z":N[I]+1--N[I]
if N[I]<=N-(Z-I);gto "out"
if I=1;gto "Z"
I-1--I
gto "z"
"out":if I=Z;gto "o"
for J=I+1 to Z
N[J-1]+1--N[J]
next J
gto "o"
"Z":next Z
"     ":
"ENTER THE RESPONSE DATA IN STANDARD FORM":
"     ":
for I=1 to R


dsp "RESPONSE", I
ent "",R[I]
next I
fmt 1,/,"FACTORIAL DESIGN ANALYSIS FOR A 2^",f1.0,"PLAN";wrt 701.1
fmt 1,/,"RESPONSE DATA (Standard Form)";wrt 701.1
cll 'LINE'(44)
for I=1 to R/2
R/2+I--J
fmt 1,f2.0,5x,f7.2,15x,f2.0,f7.2
wrt 701.1, I, R[I],J,R[J]
next I
cll 'LINE'(44)
"     ":
"COMPUTE THE REGRESSION COEFFICIENTS AND THE ASSOCIATED SSQ":
"     ":
for J=1 to R
0--S
for I=1 to R
S+D[I,J]*R[I]--S
next I
S/R--C[J,1]
R*C[J,1]^2--C[J,2]
next J
for I=1 to R
len(B$[I])+1--L
for J=L to 10
" "--B$[I,J]
next J
next I
fmt 1,/,/,"RESULTS OF THE REGRESSION",/;wrt 701.1
fmt 1,"TERM",6x,"COEFF.",4x,"SUM OF SQR",5x,z
wrt 701.1;wrt 701.1;fmt ;wrt 701
cll 'LINE' (66)
fmt 1,c,f7.2,3x,f7.1,6x,c,f7.2,3x,f7.1
for J=1 to R/2
R/2+J--K
wrt 701.1,B$[J],C[J,1],C[J,2],B$[K],C[K,1],C[K,2]
next J
cll 'LINE'(66)
"     ":
"CALCULATION OF THE STEPWISE REGRESSION":
"     ":
for I=1 to R-1
0--S--T
for J=2 to R
if O[J,1]=1;gto "pass"
if C[J,2]>S;C[J,2]--S;J--T
"pass":next J
1--O[T,1];T--O[I,2]
next I
0--S
for I=2 to R
S+C[I,2]--S
next I
fmt 1,/,/,"RESULTS OF THE STEPWISE REGRESSION";wrt 701.1
fmt 1,/,"TERM",6x,"S OF SQRS",4x,"F ENTRY",3x,"D.F.",6x,"R**2"
wrt 701.1
cll 'LINE' (66)
1--M;S--T
for I=1 to R-1
```

```
    121        C[I,2]→J
    122        1+M→M;T-C[J,2]→T;1-T/S→C
    123        R-M→G
    124        1→F;if I=R-1;gto "bye"
    125        S*C[J,2]/T→F
    126        "bye":fmt 1,c,f8.2,2x,f8.2,2x,f4.0,6x,f7.4
    127        wrt 701.1,B$[J],C[J,2],F,G,C
    128        next I
    129        cll 'LINE' (58)
    130        stp
    131        "LINE":for V=1 to p1;fmt 9,"-",z;wrt 701.9;next V;fmt ;wrt 701;re
End of file
```

11. APPENDIX V

Output Of A Conventional Stepwise Linear Regression From The BMDP Statistical Package

```
PAGE   1 BMDP

BMDP2R - STEPWISE REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL     1982
MANUAL REVISED -- 1981
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TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH

MAR 11, 1985         AT 20:56:27

PROGRAM CONTROL INFORMATION

/PROBLEM    TITLE IS 'S.L.R. FOR PHI OF WATER REC: MODELLING SERIE'.
/INPUT      VARIABLES ARE 5.
            FORMAT IS '(7F10.1)'.
            CASES ARE 30.
            MTSFILE IS MOREG31.
/VARIABLES  NAMES ARE PHI,X1,X2,X3,X4,X12,X13,X14,X23,X24,
            X34,X123,X124,X134,X234,
            X1234,X11,X22,X33,X44.
            ADD=15.
/TRANS      X12=X1*X2.
            X13=X1*X3.
            X14=X1*X4.
            X23=X2*X3.
            X24=X2*X4.
            X34=X3*X4.
            X123=X1*X2*X3.
            X124=X1*X2*X4.
            X134=X1*X3*X4.
            X234=X2*X3*X4.
            X1234=X1*X2*X3*X4.
            X11=X1*X1.
            X22=X2*X2.
            X33=X3*X3.
            X44=X4*X4.
/REGRESS    DEPENDENT IS PHI.
/PRINT      DATA.
            FRATIO.
/END

PROBLEM TITLE IS
S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

NUMBER OF VARIABLES TO READ IN. . . . . . . . . .         5
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .          15
TOTAL NUMBER OF VARIABLES . . . . . . . . . . . .        20
NUMBER OF CASES TO READ IN. . . . . . . . . . . .        30
CASE LABELING VARIABLES
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. . .   NEITHER
BLANKS ARE . . . . . . . . . . . . . . . . . . . .   MISSING
INPUT FILE. . . . . . . . UNIT    7 . . . . . .     MOREG31
REWIND INPUT UNIT PRIOR TO READING.   DATA. . .         YES




NUMBER OF WORDS OF DYNAMIC STORAGE . . . . . .         8190
NUMBER OF CASES DESCRIBED BY INPUT FORMAT . . .           1

***** TRAN     PARAGRAPH IS USED *****

VARIABLES TO BE USED
     1 PHI          2 X1           3 X2           4 X3           5 X4
     6 X12          7 X13          8 X14          9 X23         10 X24
    11 X34         12 X123        13 X124        14 X134        15 X234
    16 X1234       17 X11         18 X22         19 X33         20 X44

INPUT FORMAT IS
(7F10.1)

MAXIMUM LENGTH DATA RECORD IS   50 CHARACTERS.

I N P U T   V A R I A B L E S . . . .
  VARIABLE .    RECORD   COLUMNS      FIELD  TYPE               VARIABLE       RECORD   COLUMNS      FIELD  TYPE
 INDEX   NAME     NO.   BEGIN  END    WIDTH                   INDEX   NAME       NO.   BEGIN  END    WIDTH
 ----- --------  ----   ----- -----   -----  ----             ----- --------   ----   ----- -----   -----  ----
     1 PHI          1       1    10    10.1   F                   4 X3            1      31    40    10.1   F
     2 X1           1      11    20    10.1   F                   5 X4            1      41    50    10.1   F
     3 X2           1      21    30    10.1   F

REGRESSION INTERCEPT. . . . . . . . . . . . . . . NON ZERO
WEIGHT VARIABLE . . . . . . . . . . . . . . . . .
PRINT COVARIANCE MATRIX . . . . . . . . . . . . .       NO
PRINT CORRELATION MATRIX. . . . . . . . . . . . .       NO
PRINT ANOVA AT EACH STEP. . . . . . . . . . . . .      YES
PRINT STEP OUTPUT . . . . . . . . . . . . . . . .      YES
PRINT REGRESSION COEFFICIENT SUMMARY TABLE. . . .      YES
PRINT PARTIAL CORRELATION SUMMARY TABLE . . . . .       NO
PRINT F-RATIO SUMMARY TABLE . . . . . . . . . . .      YES
PRINT SUMMARY TABLE . . . . . . . . . . . . . . .      YES
PRINT RESIDUALS AND DATA. . . . . . . . . . . . .      YES
PRINT CORRELATION OF REGRESSION COEFFICIENTS. . .       NO
PRINT NORMAL PROBABILITY PLOT . . . . . . . . . .       NO
PRINT DETRENDED NORMAL PROBABILITY PLOT . . . . .       NO

BASED ON INPUT FORMAT SUPPLIED    1 RECORDS READ PER CASE.

NUMBER OF CASES READ. . . . . . . . . . . . . . .       30
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PAGE    3  BMDP    S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

   VARIABLE                         STANDARD    COEFFICIENT                                  SMALLEST        LARGEST       SMALLEST       LARGEST
NO     NAME           MEAN         DEVIATION   OF VARIATION      SKEWNESS       KURTOSIS       VALUE          VALUE       STD SCORE     STD SCORE
  1   PHI            93.0002         3.3819      0.036364        -0.9474         0.8424       83.2100        98.1000        -2.8949        1.5080
  2   X1             -0.0000         0.7878***************       -0.0000        -1.4428       -1.0000         1.0000        -1.2693        1.2693
  3   X2             -0.0000         0.7878***************       -0.0000        -1.4428       -1.0000         1.0000        -1.2693        1.2693
  4   X3             -0.0000         0.7878***************       -0.0000        -1.4428       -1.0000         1.0000        -1.2693        1.2693
  5   X4             -0.0000         0.7878***************       -0.0000        -1.4428       -1.0000         1.0000        -1.2693        1.2693
  6   X12             0.0000         0.7428***************        0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
  7   X13            -0.0000         0.7428***************       -0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
  8   X14             0.0            0.7428      0.0             -0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
  9   X23             0.0            0.7428      0.0             -0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 10   X24             0.0            0.7428      0.0             -0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 11   X34             0.0000         0.7428***************       -0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 12   X123            0.0000         0.7428***************        0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 13   X124            0.0000         0.7428***************        0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 14   X134            0.0000         0.7428***************        0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 15   X234            0.0            0.7428      0.0             -0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 16   X1234           0.0            0.7428      0.0              0.0000        -1.2479       -1.0000         1.0000        -1.3463        1.3463
 17   X11             0.6000         0.4983      0.830455        -0.3880        -1.9088        0.0            1.0000        -1.2042        0.8028
 18   X22             0.6000         0.4983      0.830455        -0.3880        -1.9088        0.0            1.0000        -1.2042        0.8028
 19   X33             0.6000         0.4983      0.830455        -0.3880        -1.9088        0.0            1.0000        -1.2042        0.8028
 20   X44             0.6000         0.4983      0.830455        -0.3880        -1.9088        0.0            1.0000        -1.2042        0.8028

NOTE - KURTOSIS VALUES GREATER THAN ZERO INDICATE A
       DISTRIBUTION WITH HEAVIER TAILS THAN NORMAL
       DISTRIBUTION.
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PAGE    3  BMDP    S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

REGRESSION TITLE. . . . . . .
S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

STEPPING ALGORITHM . . . . . . . . . . . . . . .F
MAXIMUM NUMBER OF STEPS . . . . . . . . . . . .       40
DEPENDENT VARIABLE . . . . . . . . . . . . . . .        1 PHI
MINIMUM ACCEPTABLE F TO ENTER . . . . . . . . .    4.000,    4.000
MAXIMUM ACCEPTABLE F TO REMOVE. . . . . . . . .    3.900,    3.900
MINIMUM ACCEPTABLE TOLERANCE. . . . . . . . . .  0.01000
SUBSCRIPTS OF THE INDEPENDENT VARIABLES . . . .    2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17
                                                   18    19    20


STEP NO.     0
---------------

STD. ERROR OF EST.       3.3819

ANALYSIS OF VARIANCE
                    SUM OF SQUARES      DF     MEAN SQUARE
       RESIDUAL      331.67993          29     11.43724

                     VARIABLES IN EQUATION                                                      VARIABLES NOT IN EQUATION

                                    STD. ERROR  STD REG                 F TO                                  PARTIAL                    F TO
     VARIABLE       COEFFICIENT     OF COEFF     COEFF     TOLERANCE   REMOVE     LEVEL.    VARIABLE             CORR.    TOLERANCE      ENTER   LEVEL
(Y-INTERCEPT         93.00023 )                                                           .
                                                                                          . X1           2  -0.30388   1.00000        2.85     1
                                                                                          . X2           3   0.19778   1.00000        1.14     1
                                                                                          . X3           4  -0.24838   1.00000        1.84     1
                                                                                          . X4           5  -0.78674   1.00000       45.48     1
                                                                                          . X12          6   0.11258   1.00000        0.36     1
                                                                                          . X13          7  -0.04008   1.00000        0.05     1
                                                                                          . X14          8  -0.24270   1.00000        1.75     1
                                                                                          . X23          9  -0.05181   1.00000        0.07     1
                                                                                          . X24         10   0.18175   1.00000        0.96     1
                                                                                          . X34         11  -0.03734   1.00000        0.04     1
                                                                                          . X123        12   0.04365   1.00000        0.05     1
                                                                                          . X124        13   0.14908   1.00000        0.64     1
                                                                                          . X134        14  -0.02189   1.00000        0.01     1
                                                                                          . X234        15  -0.03651   1.00000        0.04     1
                                                                                          . X1234       16  -0.00494   1.00000        0.00     1
                                                                                          . X11         17   0.10832   1.00000        0.33     1
                                                                                          . X22         18   0.04938   1.00000        0.07     1
                                                                                          . X33         19  -0.01784   1.00000        0.01     1
                                                                                          . X44         20   0.04859   1.00000        0.07     1


STEP NO.     1
---------------
VARIABLE ENTERED     5 X4

MULTIPLE R               0.7867
MULTIPLE R-SQUARE        0.6190
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```
ADJUSTED R-SQUARE       0.6054
STD. ERROR OF EST.      2.1245

ANALYSIS OF VARIANCE
                    SUM OF SQUARES      DF     MEAN SQUARE        F RATIO
        REGRESSION   205.29828           1   205.2983              45.48
        RESIDUAL     126.38176          28   4.513634

                   VARIABLES IN EQUATION                                          VARIABLES NOT IN EQUATION

                                STD. ERROR  STD REG                 F TO                                 PARTIAL                 F TO
    VARIABLE      COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE      LEVEL.     VARIABLE        CORR.    TOLERANCE    ENTER   LEVEL
(Y-INTERCEPT        93.00023 )                                                     .
X4          5      -3.37720        0.5006    -0.787    1.00000       45.48       1  .  X1            2 -0.49229   1.00000       8.64    1
                                                                                   .  X2            3  0.32037   1.00000       3.09    1
                                                                                   .  X3            4 -0.40234   1.00000       5.21    1
                                                                                   .  X12           6  0.18235   1.00000       0.93    1
                                                                                   .  X13           7 -0.06494   1.00000       0.11    1
                                                                                   .  X14           8 -0.39317   1.00000       4.94    1
                                                                                   .  X23           9 -0.08362   1.00000       0.19    1
                                                                                   .  X24          10  0.29443   1.00000       2.56    1
                                                                                   .  X34          11 -0.06049   1.00000       0.10    1
                                                                                   .  X123         12  0.07072   1.00000       0.14    1
                                                                                   .  X124         13  0.24151   1.00000       1.67    1
                                                                                   .  X134         14 -0.03514   1.00000       0.03    1
                                                                                   .  X234         15 -0.05915   1.00000       0.09    1
                                                                                   .  X1234        16 -0.00801   1.00000       0.00    1
                                                                                   .  X11          17  0.17547   1.00000       0.86    1
                                                                                   .  X22          18  0.08000   1.00000       0.17    1
                                                                                   .  X33          19 -0.02906   1.00000       0.02    1
                                                                                   .  X44          20  0.08033   1.00000       0.18    1

STEP NO.    2
---------------
VARIABLE ENTERED     2 X1

MULTIPLE R              0.8434
MULTIPLE R-SQUARE       0.7113
ADJUSTED R-SQUARE       0.6899
STD. ERROR OF EST.      1.8832

ANALYSIS OF VARIANCE
                    SUM OF SQUARES      DF     MEAN SQUARE        F RATIO
        REGRESSION   235.92628           2   117.9631              33.26
        RESIDUAL     95.753769          27   3.546435

                   VARIABLES IN EQUATION                                          VARIABLES NOT IN EQUATION

                                STD. ERROR  STD REG                 F TO                                 PARTIAL                 F TO
    VARIABLE      COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE      LEVEL.     VARIABLE        CORR.    TOLERANCE    ENTER   LEVEL
(Y-INTERCEPT        93.00023 )                                                     .
X1          2      -1.30444        0.4438    -0.304    1.00000        8.64       1  .  X2            3  0.36805   1.00000       4.07    1
X4          5      -3.37720        0.4438    -0.787    1.00000       57.89       1  .  X3            4 -0.46223   1.00000       7.06    1
                                                                                   .  X12           6  0.20950   1.00000       1.19    1
                                                                                   .  X13           7 -0.07460   1.00000       0.15    1
                                                                                   .  X14           8 -0.45169   1.00000       6.66    1
                                                                                   .  X23           9 -0.09606   1.00000       0.24    1
                                                                                   .  X24          10  0.33826   1.00000       3.36    1



                                                                                   .  X34          11 -0.06949   1.00000       0.13    1
                                                                                   .  X123         12  0.08124   1.00000       0.17    1
                                                                                   .  X124         13  0.27745   1.00000       2.17    1
                                                                                   .  X134         14 -0.04037   1.00000       0.04    1
                                                                                   .  X234         15 -0.06796   1.00000       0.12    1
                                                                                   .  X1234        16 -0.00920   1.00000       0.00    1
                                                                                   .  X11          17  0.20159   1.00000       1.10    1
                                                                                   .  X22          18  0.09191   1.00000       0.22    1
                                                                                   .  X33          19 -0.03339   1.00000       0.03    1
                                                                                   .  X44          20  0.09229   1.00000       0.22    1

STEP NO.    3
---------------
VARIABLE ENTERED     4 X3

MULTIPLE R              0.8792
MULTIPLE R-SQUARE       0.7730
ADJUSTED R-SQUARE       0.7468
STD. ERROR OF EST.      1.7018

ANALYSIS OF VARIANCE
                    SUM OF SQUARES      DF     MEAN SQUARE        F RATIO
        REGRESSION   256.38428           3   85.46143              29.51
        RESIDUAL     75.295624          26   2.895985

                   VARIABLES IN EQUATION                                          VARIABLES NOT IN EQUATION

                                STD. ERROR  STD REG                 F TO                                 PARTIAL                 F TO
    VARIABLE      COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE      LEVEL.     VARIABLE        CORR.    TOLERANCE    ENTER   LEVEL
(Y-INTERCEPT        93.00023 )                                                     .
X1          2      -1.30444        0.4011    -0.304    1.00000       10.58       1  .  X2            3  0.41505   1.00000       5.20    1
X3          4      -1.06610        0.4011    -0.248    1.00000        7.06       1  .  X12           6  0.23625   1.00000       1.48    1
X4          5      -3.37720        0.4011    -0.787    1.00000       70.89       1  .  X13           7 -0.08413   1.00000       0.18    1
                                                                                   .  X14           8 -0.50938   1.00000       8.76    1
                                                                                   .  X23           9 -0.10833   1.00000       0.30    1
                                                                                   .  X24          10  0.38145   1.00000       4.26    1
                                                                                   .  X34          11 -0.07836   1.00000       0.15    1
                                                                                   .  X123         12  0.09162   1.00000       0.21    1
                                                                                   .  X124         13  0.31288   1.00000       2.71    1
                                                                                   .  X134         14 -0.04552   1.00000       0.05    1
                                                                                   .  X234         15 -0.07664   1.00000       0.15    1
                                                                                   .  X1234        16 -0.01037   1.00000       0.00    1
                                                                                   .  X11          17  0.22734   1.00000       1.36    1
                                                                                   .  X22          18  0.10365   1.00000       0.27    1
                                                                                   .  X33          19 -0.03765   1.00000       0.04    1
                                                                                   .  X44          20  0.10408   1.00000       0.27    1

STEP NO.    4
---------------
VARIABLE ENTERED     8 X14

MULTIPLE R              0.9121
MULTIPLE R-SQUARE       0.8319
ADJUSTED R-SQUARE       0.8050
STD. ERROR OF EST.      1.4934
```

```
ANALYSIS OF VARIANCE
                     SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
        REGRESSION   275.92065            4   68.98016             30.93
        RESIDUAL     55.759201           25    2.230368

                         VARIABLES IN EQUATION                                                  VARIABLES NOT IN EQUATION

                                   STD. ERROR  STD REG                  F TO                                 PARTIAL                      F TO
     VARIABLE         COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE     LEVEL.      VARIABLE         CORR.   TOLERANCE      ENTER  LEVEL
 (Y-INTERCEPT           93.00023 )                                                      .
 X1             2       -1.30444       0.3520    -0.304    1.00000      13.73       1  . X2              3  0.48232   1.00000         7.28     1
 X3             4       -1.06610       0.3520    -0.248    1.00000       9.17       1  . X12             6  0.27453   1.00000         1.96     1
 X4             5       -3.37720       0.3520    -0.787    1.00000      92.05       1  . X13             7 -0.09776   1.00000         0.23     1
 X14            8       -1.10500       0.3734    -0.243    1.00000       8.76       1  . X23             9 -0.12586   1.00000         0.39     1
                                                                                       . X24            10  0.44327   1.00000         5.87     1
                                                                                       . X34            11 -0.09108   1.00000         0.20     1
                                                                                       . X123           12  0.10647   1.00000         0.28     1
                                                                                       . X124           13  0.36359   1.00000         3.66     1
                                                                                       . X134           14 -0.05290   1.00000         0.07     1
                                                                                       . X234           15 -0.08906   1.00000         0.19     1
                                                                                       . X1234          16 -0.01205   1.00000         0.00     1
                                                                                       . X11            17  0.26418   1.00000         1.80     1
                                                                                       . X22            18  0.12044   1.00000         0.35     1
                                                                                       . X33            19 -0.04376   1.00000         0.05     1
                                                                                       . X44            20  0.12094   1.00000         0.36     1


STEP NO.    5
---------------
VARIABLE ENTERED    3 X2

MULTIPLE R              0.9333
MULTIPLE R-SQUARE       0.8710
ADJUSTED R-SQUARE       0.8441
STD. ERROR OF EST.      1.3352

ANALYSIS OF VARIANCE
                     SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
        REGRESSION   288.89185            5   57.77837             32.41
        RESIDUAL     42.788010           24    1.782833

                         VARIABLES IN EQUATION                                                  VARIABLES NOT IN EQUATION

                                   STD. ERROR  STD REG                  F TO                                 PARTIAL                      F TO
     VARIABLE         COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE     LEVEL.      VARIABLE         CORR.   TOLERANCE      ENTER  LEVEL
 (Y-INTERCEPT           93.00023 )                                                      .
 X1             2       -1.30444       0.3147    -0.304    1.00000      17.18       1  . X12             6  0.31340   1.00000         2.51     1
 X2             3        0.84889       0.3147     0.198    1.00000       7.28       1  . X13             7 -0.11160   1.00000         0.29     1
 X3             4       -1.06610       0.3147    -0.248    1.00000      11.48       1  . X23             9 -0.14370   1.00000         0.48     1
 X4             5       -3.37720       0.3147    -0.787    1.00000     115.16       1  . X24            10  0.50602   1.00000         7.92     1
 X14            8       -1.10500       0.3338    -0.243    1.00000      10.96       1  . X34            11 -0.10395   1.00000         0.25     1
                                                                                       . X123           12  0.12154   1.00000         0.34     1
                                                                                       . X124           13  0.41506   1.00000         4.79     1
                                                                                       . X134           14 -0.06039   1.00000         0.08     1
                                                                                       . X234           15 -0.10188   1.00000         0.24     1
                                                                                       . X1234          16 -0.01378   1.00000         0.00     1
                                                                                       . X11            17  0.30157   1.00000         2.30     1
                                                                                       . X22            18  0.13749   1.00000         0.44     1
                                                                                       . X33            19 -0.04995   1.00000         0.06     1




                                                                                       . X44            20  0.13806   1.00000         0.45     1


STEP NO.    6
---------------
VARIABLE ENTERED   10 X24

MULTIPLE R              0.9508
MULTIPLE R-SQUARE       0.9040
ADJUSTED R-SQUARE       0.8790
STD. ERROR OF EST.      1.1764

ANALYSIS OF VARIANCE
                     SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
        REGRESSION   299.84790            6   49.97465             36.11
        RESIDUAL     31.831940           23    1.383997

                         VARIABLES IN EQUATION                                                  VARIABLES NOT IN EQUATION

                                   STD. ERROR  STD REG                  F TO                                 PARTIAL                      F TO
     VARIABLE         COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE     LEVEL.      VARIABLE         CORR.   TOLERANCE      ENTER  LEVEL
 (Y-INTERCEPT           93.00023 )                                                      .
 X1             2       -1.30444       0.2773    -0.304    1.00000      22.13       1  . X12             6  0.36335   1.00000         3.35     1
 X2             3        0.84889       0.2773     0.198    1.00000       9.37       1  . X13             7 -0.12939   1.00000         0.37     1
 X3             4       -1.06610       0.2773    -0.248    1.00000      14.78       1  . X23             9 -0.16661   1.00000         0.63     1
 X4             5       -3.37720       0.2773    -0.787    1.00000     148.34       1  . X34            11 -0.12052   1.00000         0.32     1
 X14            8       -1.10500       0.2941    -0.243    1.00000      14.12       1  . X123           12  0.14091   1.00000         0.45     1
 X24           10        0.82750       0.2941     0.182    1.00000       7.92       1  . X124           13  0.48121   1.00000         6.63     1
                                                                                       . X134           14 -0.07001   1.00000         0.11     1
                                                                                       . X234           15 -0.11787   1.00000         0.31     1
                                                                                       . X1234          16 -0.01595   1.00000         0.01     1
                                                                                       . X11            17  0.34964   1.00000         3.06     1
                                                                                       . X22            18  0.15941   1.00000         0.57     1
                                                                                       . X33            19 -0.05791   1.00000         0.07     1
                                                                                       . X44            20  0.16007   1.00000         0.58     1


STEP NO.    7
---------------
VARIABLE ENTERED   13 X124

MULTIPLE R              0.9624
MULTIPLE R-SQUARE       0.9263
ADJUSTED R-SQUARE       0.9028
STD. ERROR OF EST.      1.0544

ANALYSIS OF VARIANCE
                     SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
        REGRESSION   307.21924            7   43.88846             39.47
        RESIDUAL     24.460754           22    1.111852

                         VARIABLES IN EQUATION                                                  VARIABLES NOT IN EQUATION

                                   STD. ERROR  STD REG                  F TO                                 PARTIAL                      F TO
     VARIABLE         COEFFICIENT   OF COEFF     COEFF     TOLERANCE   REMOVE     LEVEL.      VARIABLE         CORR.   TOLERANCE      ENTER  LEVEL
 (Y-INTERCEPT           93.00023 )                                                      .
 X1             2       -1.30444       0.2485    -0.304    1.00000      27.55       1  . X12             6  0.41449   1.00000         4.36     1
 X2             3        0.84889       0.2485     0.198    1.00000      11.67       1  . X13             7 -0.14760   1.00000         0.47     1
```

```
X3            4     -1.06610      0.2485  -0.248   1.00000       18.40      1  . X23           9 -0.19006  1.00000        0.79   1
X4            5     -3.37720      0.2485  -0.787   1.00000      184.64      1  . X34          11 -0.13749  1.00000        0.40   1
X14           8     -1.10500      0.2636  -0.243   1.00000       17.57      1  . X123         12  0.16074  1.00000        0.56   1
X24          10      0.82750      0.2636   0.182   1.00000        9.85      1  . X134         14 -0.07887  1.00000        0.13   1
X124         13      0.67875      0.2636   0.149   1.00000        6.63      1  . X234         15 -0.13446  1.00000        0.39   1
                                                                                . X1234        16 -0.01820  1.00000        0.01   1
                                                                                . X11          17  0.39886  1.00000        3.97   1
                                                                                . X22          18  0.18185  1.00000        0.72   1
                                                                                . X33          19 -0.06606  1.00000        0.09   1
                                                                                . X44          20  0.18250  1.00000        0.72   1


STEP NO.    8
---------------
VARIABLE ENTERED     6 X12

MULTIPLE R               0.9690
MULTIPLE R-SQUARE        0.9389
ADJUSTED R-SQUARE        0.9157
STD. ERROR OF EST.       0.9822

ANALYSIS OF VARIANCE
                   SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
       REGRESSION  311.42163            8   38.92770            40.35
       RESIDUAL     20.258270          21  0.9646795

                       VARIABLES IN EQUATION                            .              VARIABLES NOT IN EQUATION
                                                                        .
                              STD. ERROR  STD REG                F TO   .                     PARTIAL               F TO
    VARIABLE      COEFFICIENT  OF COEFF    COEFF    TOLERANCE   REMOVE    LEVEL.    VARIABLE   CORR.   TOLERANCE    ENTER  LEVEL
(Y-INTERCEPT        93.00023 )                                          .
X1            2     -1.30444      0.2315  -0.304   1.00000       31.75      1  . X13           7 -0.16219  1.00000        0.54   1
X2            3      0.84889      0.2315   0.198   1.00000       13.45      1  . X23           9 -0.20885  1.00000        0.91   1
X3            4     -1.06610      0.2315  -0.248   1.00000       21.21      1  . X34          11 -0.15106  1.00000        0.47   1
X4            5     -3.37720      0.2315  -0.787   1.00000      212.81      1  . X123         12  0.17663  1.00000        0.64   1
X12           6      0.51250      0.2455   0.113   1.00000        4.36      1  . X134         14 -0.08776  1.00000        0.16   1
X14           8     -1.10500      0.2455  -0.243   1.00000       20.26      1  . X234         15 -0.14775  1.00000        0.45   1
X24          10      0.82750      0.2455   0.182   1.00000       11.36      1  . X1234        16 -0.02000  1.00000        0.01   1
X124         13      0.67875      0.2455   0.149   1.00000        7.64      1  . X11          17  0.43828  1.00000        4.76   1
                                                                                . X22          18  0.19962  1.00000        0.83   1
                                                                                . X33          19 -0.07259  1.00000        0.11   1
                                                                                . X44          20  0.20065  1.00000        0.84   1


STEP NO.    9
---------------
VARIABLE ENTERED    17 X11

MULTIPLE R               0.9750
MULTIPLE R-SQUARE        0.9507
ADJUSTED R-SQUARE        0.9284
STD. ERROR OF EST.       0.9046

ANALYSIS OF VARIANCE
                   SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
       REGRESSION  315.31299            9   35.03477            42.81
       RESIDUAL     16.366852          20  0.8183426



                       VARIABLES IN EQUATION                            .              VARIABLES NOT IN EQUATION
                                                                        .
                              STD. ERROR  STD REG                F TO   .                     PARTIAL               F TO
    VARIABLE      COEFFICIENT  OF COEFF    COEFF    TOLERANCE   REMOVE    LEVEL.    VARIABLE   CORR.   TOLERANCE    ENTER  LEVEL
(Y-INTERCEPT        92.55911 )                                          .
X1            2     -1.30444      0.2132  -0.304   1.00000       37.43      1  . X13           7 -0.18044  1.00000        0.64   1
X2            3      0.84889      0.2132   0.198   1.00000       15.85      1  . X23           9 -0.23235  1.00000        1.08   1
X3            4     -1.06610      0.2132  -0.248   1.00000       25.00      1  . X34          11 -0.16808  1.00000        0.55   1
X4            5     -3.37720      0.2132  -0.787   1.00000      250.87      1  . X123         12  0.19851  1.00000        0.78   1
X12           6      0.51250      0.2262   0.113   1.00000        5.14      1  . X134         14 -0.09764  1.00000        0.18   1
X14           8     -1.10500      0.2262  -0.243   1.00000       23.87      1  . X234         15 -0.16437  1.00000        0.53   1
X24          10      0.82750      0.2262   0.182   1.00000       13.38      1  . X1234        16 -0.02226  1.00000        0.01   1
X124         13      0.67875      0.2262   0.149   1.00000        9.01      1  . X22          18 -0.18774  0.47840        0.69   1
X11          17      0.73517      0.3371   0.108   1.00000        4.76      1  . X33          19 -0.62592  0.47840       12.24   1
                                                                                . X44          20 -0.18641  0.47840        0.68   1


STEP NO.   10
---------------
VARIABLE ENTERED    19 X33

MULTIPLE R               0.9849
MULTIPLE R-SQUARE        0.9700
ADJUSTED R-SQUARE        0.9542
STD. ERROR OF EST.       0.7238

ANALYSIS OF VARIANCE
                   SUM OF SQUARES      DF     MEAN SQUARE       F RATIO
       REGRESSION  321.72510           10   32.17250            61.41
       RESIDUAL      9.9547520         19  0.5239343
                       VARIABLES IN EQUATION                            .              VARIABLES NOT IN EQUATION
                                                                        .
                              STD. ERROR  STD REG                F TO   .                     PARTIAL               F TO
    VARIABLE      COEFFICIENT  OF COEFF    COEFF    TOLERANCE   REMOVE    LEVEL.    VARIABLE   CORR.   TOLERANCE    ENTER  LEVEL
(Y-INTERCEPT        92.78651 )                                          .
X1            2     -1.30444      0.1706  -0.304   1.00000       58.46      1  . X13           7 -0.23137  1.00000        1.02   1
X2            3      0.84889      0.1706   0.198   1.00000       24.76      1  . X23           9 -0.29793  1.00000        1.75   1
X3            4     -1.06610      0.1706  -0.248   1.00000       39.05      1  . X34          11 -0.21552  1.00000        0.88   1
X4            5     -3.37720      0.1706  -0.787   1.00000      391.84      1  . X123         12  0.25197  1.00000        1.22   1
X12           6      0.51250      0.1810   0.113   1.00000        8.02      1  . X134         14 -0.12519  1.00000        0.29   1
X14           8     -1.10500      0.1810  -0.243   1.00000       37.29      1  . X234         15 -0.21077  1.00000        0.84   1
X24          10      0.82750      0.1810   0.182   1.00000       20.91      1  . X1234        16 -0.02852  1.00000        0.01   1
X124         13      0.67875      0.1810   0.149   1.00000       14.07      1  . X22          18  0.10556  0.39427        0.20   1
X11          17      1.72057      0.3900   0.253   0.47840       19.46      1  . X44          20  0.10745  0.39427        0.21   1
X33          19     -1.36440      0.3900  -0.201   0.47840       12.24      1  .

* * * * * F-LEVELS(   4.000,    3.900) OR TOLERANCE INSUFFICIENT FOR FURTHER STEPPING
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PAGE   4  BMDP   S.L.R  FOR PHI OF WATER REC: MODELLING SERIE

                                     STEPWISE REGRESSION COEFFICIENTS

  VARIABLES   0 Y-INTCPT  2 X1          3 X2          4 X3          5 X4          6 X12         7 X13         8 X14         9 X23         10 X24
STEP
    0          93.0002*     -1.3044       0.8489       -1.0661       -3.3772        0.5125       -0.1825       -1.1050       -0.2350        0.8275
    1          93.0002*     -1.3044       0.8489       -1.0661       -3.3772*       0.5125       -0.1825       -1.1050       -0.2350        0.8275
    2          93.0002*     -1.3044*      0.8489       -1.0661       -3.3772*       0.5125       -0.1825       -1.1050       -0.2350        0.8275
    3          93.0002*     -1.3044*      0.8489       -1.0661*      -3.3772*       0.5125       -0.1825       -1.1050       -0.2350        0.8275
    4          93.0002*     -1.3044*      0.8489       -1.0661*      -3.3772*       0.5125       -0.1825       -1.1050*      -0.2350        0.8275
    5          93.0002*     -1.3044*      0.8489*      -1.0661*      -3.3772*       0.5125       -0.1825       -1.1050*      -0.2350        0.8275
    6          93.0002*     -1.3044*      0.8489*      -1.0661*      -3.3772*       0.5125       -0.1825       -1.1050*      -0.2350        0.8275*
    7          93.0002*     -1.3044*      0.8489*      -1.0661*      -3.3772*       0.5125       -0.1825       -1.1050*      -0.2350        0.8275*
    8          93.0002*     -1.3044*      0.8489*      -1.0661*      -3.3772*       0.5125*      -0.1825       -1.1050*      -0.2350        0.8275*
    9          92.5591*     -1.3044*      0.8489*      -1.0661*      -3.3772*       0.5125*      -0.1825       -1.1050*      -0.2350        0.8275*
   10          92.7865*     -1.3044*      0.8489*      -1.0661*      -3.3772*       0.5125*      -0.1825       -1.1050*      -0.2350        0.8275*

NOTE - 1) REGRESSION COEFFICIENTS FOR VARIABLE IN THE
          EQUATION ARE INDICATED BY AN ASTERISK
       2) THE REMAINING COEFFICIENTS ARE THOSE WHICH WOULD
          BE OBTAINED IF THAT VARIABLE WERE TO ENTER IN THE
          NEXT STEP


                                     STEPWISE REGRESSION COEFFICIENTS

  VARIABLES  11 X34        12 X123       13 X124       14 X134       15 X234       16 X1234      17 X11        18 X22        19 X33        20 X44
STEP
    0          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    1          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    2          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    3          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    4          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    5          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    6          -0.1700       0.1988        0.6787       -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    7          -0.1700       0.1988        0.6787*      -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    8          -0.1700       0.1988        0.6787*      -0.0988       -0.1662       -0.0225        0.7352        0.3352       -0.1218        0.3366
    9          -0.1700       0.1988        0.6787*      -0.0988       -0.1662       -0.0225        0.7352*      -0.4082       -1.3644       -0.4063
   10          -0.1700       0.1988        0.6787*      -0.0988       -0.1662       -0.0225        1.7206*       0.1977       -1.3644*       0.2012

NOTE - 1) REGRESSION COEFFICIENTS FOR VARIABLE IN THE
          EQUATION ARE INDICATED BY AN ASTERISK
       2) THE REMAINING COEFFICIENTS ARE THOSE WHICH WOULD
          BE OBTAINED IF THAT VARIABLE WERE TO ENTER IN THE
          NEXT STEP
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PAGE   5  BMDP   S.L.R  FOR PHI OF WATER REC. MODELLING SERIE

                                     F-TO-ENTER OR F-TO-REMOVE OF EACH VARIABLE AT EACH STEP

  VARIABLES   2 X1          3 X2          4 X3          5 X4          6 X12         7 X13         8 X14         9 X23         10 X24        11 X34
STEP
    0           2.8465        1.1398        1.8406       45.4640        0.3593        0.0451        1.7525        0.0748        0.9585        0.0391
    1           8.6363        3.0661        5.2148       45.4640*       0.8287        0.1143        4.9368        0.1901        2.5628        0.0991
    2           8.6363*       4.0739        7.0643       57.8885*       1.1935        0.1455        6.6544        0.2422        3.3593        0.1282
    3          10.5760*       5.2031        7.0643*      70.8805*       1.4778        0.1782        8.7593        0.2968        4.2571        0.1645
    4          13.7322*       7.2756        9.1725*      92.0457*       1.8563        0.2316        8.7593*       0.3884        5.8689        0.2007
    5          17.1783*       7.2756*      11.4751*     115.1527*       2.5050        0.2901       10.9581*       0.4850        7.9162        0.2513
    6          22.1300*       9.3722*      14.7619*     148.3369*       3.3462        0.3746       14.1159*       0.6281        7.9162*       0.3243
    7          27.5467*      11.6663*      18.4000*     184.8449*       4.3564        0.4677       17.5710*       0.7870        9.6539*       0.4048
    8          31.7483*      13.4461*      21.2072*     212.8148*       4.3564*       0.5403       20.2517*       0.9121       11.3572*       0.4672
    9          37.4267*      15.8505*      24.9984*     250.8702*       5.1354*       0.6385       23.8731*       1.0843       13.3881*       0.5524
   10          68.4575*      24.7572*      39.0471*     351.8389*       8.0210*       1.0181       37.2879*       1.7533       20.9111*       0.8768


                                     F-TO-ENTER OR F-TO-REMOVE OF EACH VARIABLE AT EACH STEP

  VARIABLES  12 X123       13 X124       14 X134       15 X234       16 X1234      17 X11        18 X22        19 X33        20 X44
STEP
    0           0.0835        0.8384        0.0132        0.0374        0.0007        0.3324        0.0685        0.0090        0.0690
    1           0.1357        1.6723        0.0334        0.0848        0.0017        0.6576        0.1739        0.0228        0.1754
    2           0.1728        2.1684        0.0424        0.1206        0.0022        1.1014        0.2215        0.0290        0.2234
    3           0.2118        2.7130        0.0519        0.1477        0.0027        1.3525        0.2715        0.0355        0.2738
    4           0.2752        3.8560        0.0673        0.1918        0.0035        1.8006        0.3533        0.0460        0.3563
    5           0.3448        4.7869        0.0842        0.2402        0.0044        2.3010        0.4432        0.0575        0.4459
    6           0.4457        6.6286        0.1084        0.3099        0.0056        3.0641        0.5735        0.0740        0.5765
    7           0.5570        6.6286*       0.1348        0.3866        0.0070        3.5729        0.7182        0.0921        0.7244
    8           0.6441        7.6411*       0.1552        0.4463        0.0080        4.7552        0.8318        0.1060        0.8390
    9           0.7632        9.0074*       0.1828        0.5276        0.0094        4.7552*       0.6942       12.2364        0.6840
   10           1.2203       14.0689*       0.2866        0.8368        0.0147       19.4519*       0.2029       12.2364*       0.2103
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PAGE    6  BMDP    S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

SUMMARY TABLE
STEP          VARIABLE                   MULTIPLE       INCREASE         F-TO-          F-TO-  NUMBER OF INDEPENDENT
 NO.    ENTERED       REMOVED            R        RSQ     IN RSQ          ENTER          REMOVE   VARIABLES INCLUDED
   1     5 X4                         0.7867   0.6190   0.6190        45.4840                          1
   2     2 X1                         0.8434   0.7113   0.0923         8.6363                          2
   3     4 X3                         0.8792   0.7730   0.0617         7.0643                          3
   4     8 X14                        0.9121   0.8319   0.0589         8.7593                          4
   5     3 X2                         0.9333   0.8710   0.0391         7.2756                          5
   6    10 X24                        0.9508   0.9040   0.0330         7.9162                          6
   7    13 X124                       0.9624   0.9263   0.0222         8.6296                          7
   8     6 X12                        0.9690   0.9389   0.0127         4.3564                          8
   9    17 X11                        0.9750   0.9507   0.0117         4.7552                          9
  10    19 X33                        0.9849   0.9700   0.0193        12.2384                         10
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PAGE    7  BMDP    S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

LIST OF PREDICTED VALUES, RESIDUALS, AND VARIABLES
     NOTE - NEGATIVE CASE NUMBER DENOTES A CASE WITH MISSING VALUES.
     THE NUMBER OF STANDARD DEVIATIONS FROM THE MEAN IS DENOTED BY UP TO 3 ASTERISKS TO THE RIGHT
        OF EACH RESIDUAL OR VARIABLE.
      MISSING VALUES AND VALUES OUT OF RANGE ARE DENOTED
      BY VALUES GREATER THAN OR EQUAL TO     0.2127E+38 IN ABSOLUTE VALUE.
     MISSING VALUES ARE DENOTED BY MORE THAN THREE ASTERISKS.

    CASE                                                  VARIABLES
  NO. LABEL         PREDICTED      RESIDUAL     WEIGHT     1 PHI          2 X1           3 X2           4 X3           5 X4           6 X12
    1                 97.80       -0.8776          1.000     96.92         -1.000         -1.000         -1.000         -1.000          1.000
    2                 97.53       -0.1614          1.000     97.37          1.000         -1.000         -1.000         -1.000         -1.000
    3                 97.97        0.1268          1.000     98.10         -1.000          1.000         -1.000         -1.000         -1.000
    4                 97.24       -0.2417          1.000     97.00          1.000          1.000         -1.000         -1.000          1.000
    5                 95.47        0.7044          1.000     96.17         -1.000         -1.000          1.000         -1.000          1.000
    6                 95.40        0.7835E-03      1.000     95.40          1.000         -1.000          1.000         -1.000         -1.000
    7                 95.84        0.3491          1.000     96.19         -1.000          1.000          1.000         -1.000         -1.000
    8                 95.11        0.5305          1.000     95.64          1.000          1.000          1.000         -1.000          1.000
    9                 92.76       -0.8759    *     1.000     91.88         -1.000         -1.000         -1.000          1.000          1.000
   10                 85.55       -0.5450E-01      1.000     85.50          1.000         -1.000         -1.000          1.000         -1.000
   11                 93.72        0.5038          1.000     94.23         -1.000          1.000         -1.000          1.000         -1.000
   12                 91.29        0.6202          1.000     91.91          1.000          1.000         -1.000          1.000          1.000
   13                 90.62        0.7963    *     1.000     91.42         -1.000         -1.000          1.000          1.000          1.000
   14                 93.42       -0.2123          1.000     93.21          1.000         -1.000          1.000          1.000         -1.000
   15                 91.59       -0.1340          1.000     91.46         -1.000          1.000          1.000          1.000         -1.000
   16                 89.16       -0.4376          1.000     88.72          1.000          1.000          1.000          1.000          1.000
   17                 92.79        0.2636          1.000     93.05         0.0            0.0            0.0            0.0            0.0
   18                 92.79        0.4235          1.000     93.21         0.0            0.0            0.0            0.0            0.0
   19                 92.79        0.5348E-01      1.000     92.84         0.0            0.0            0.0            0.0            0.0
   20                 92.79        0.6435          1.000     93.43         0.0            0.0            0.0            0.0            0.0
   21                 92.79       -0.6516E-02      1.000     92.78         0.0            0.0            0.0            0.0            0.0
   22                 92.79       -0.6516E-02      1.000     92.78         0.0            0.0            0.0            0.0            0.0
   23                 95.81       -0.7915    *     1.000     95.02         -1.000         0.0            0.0            0.0            0.0
   24                 93.20       -0.4265E-01      1.000     93.16          1.000         0.0            0.0            0.0            0.0
   25                 91.94        0.7624    *     1.000     92.70         0.0           -1.000          0.0            0.0            0.0
   26                 93.84       -1.035     *     1.000     92.80         0.0            1.000          0.0            0.0            0.0
   27                 92.49        0.7618    *     1.000     93.25         0.0            0.0           -1.000          0.0            0.0
   28                 90.36       -1.596     **    1.000     88.76         0.0            0.0            1.000          0.0            0.0
   29                 96.16       -0.3437          1.000     95.82         0.0            0.0            0.0           -1.000          0.0
   30                 89.41        0.8067E-01      1.000     89.49         0.0            0.0            0.0            1.000          0.0

EACH ASTERISK REPRESENTS ONE STANDARD DEVIATION
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PAGE   8  BMDP   S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

LIST OF PREDICTED VALUES, RESIDUALS, AND VARIABLES (CONTINUED)

   CASE                        VARIABLES
 NO. LABEL       7 X13          8 X14          9 X23         10 X24         11 X34         12 X123        13 X124        14 X134        15 X234
    1             1.000          1.000          1.000          1.000          1.000         -1.000         -1.000         -1.000         -1.000
    2            -1.000         -1.000          1.000          1.000          1.000          1.000          1.000          1.000         -1.000
    3             1.000          1.000         -1.000         -1.000          1.000          1.000          1.000         -1.000          1.000
    4            -1.000         -1.000         -1.000         -1.000          1.000         -1.000         -1.000          1.000          1.000
    5            -1.000          1.000         -1.000          1.000         -1.000          1.000         -1.000          1.000          1.000
    6             1.000         -1.000         -1.000          1.000         -1.000         -1.000          1.000         -1.000          1.000
    7            -1.000          1.000          1.000         -1.000         -1.000         -1.000          1.000          1.000         -1.000
    8             1.000         -1.000          1.000         -1.000         -1.000          1.000         -1.000         -1.000         -1.000
    9             1.000         -1.000          1.000         -1.000         -1.000         -1.000          1.000          1.000          1.000
   10            -1.000          1.000          1.000         -1.000         -1.000          1.000         -1.000         -1.000          1.000
   11             1.000         -1.000         -1.000          1.000         -1.000          1.000         -1.000          1.000         -1.000
   12            -1.000          1.000         -1.000          1.000         -1.000         -1.000          1.000         -1.000         -1.000
   13            -1.000         -1.000         -1.000         -1.000          1.000          1.000          1.000         -1.000         -1.000
   14             1.000          1.000         -1.000         -1.000          1.000         -1.000         -1.000          1.000         -1.000
   15            -1.000         -1.000          1.000          1.000          1.000         -1.000         -1.000         -1.000          1.000
   16             1.000          1.000          1.000          1.000          1.000          1.000          1.000          1.000          1.000
   17            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   18            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   19            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   20            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   21            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   22            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   23            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   24            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   25            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   26            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   27            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   28            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   29            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
   30            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
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PAGE   9  BMDP   S.L.R. FOR PHI OF WATER REC: MODELLING SERIE

LIST OF PREDICTED VALUES, RESIDUALS, AND VARIABLES (CONTINUED)

   CASE                        VARIABLES
 NO. LABEL      16 X1234        17 X11         18 X22         19 X33         20 X44
    1             1.000          1.000          1.000          1.000          1.000
    2            -1.000          1.000          1.000          1.000          1.000
    3            -1.000          1.000          1.000          1.000          1.000
    4             1.000          1.000          1.000          1.000          1.000
    5            -1.000          1.000          1.000          1.000          1.000
    6             1.000          1.000          1.000          1.000          1.000
    7             1.000          1.000          1.000          1.000          1.000
    8            -1.000          1.000          1.000          1.000          1.000
    9            -1.000          1.000          1.000          1.000          1.000
   10             1.000          1.000          1.000          1.000          1.000
   11             1.000          1.000          1.000          1.000          1.000
   12            -1.000          1.000          1.000          1.000          1.000
   13             1.000          1.000          1.000          1.000          1.000
   14            -1.000          1.000          1.000          1.000          1.000
   15            -1.000          1.000          1.000          1.000          1.000
   16             1.000          1.000          1.000          1.000          1.000
   17            0.0            0.0            0.0            0.0            0.0
   18            0.0            0.0            0.0            0.0            0.0
   19            0.0            0.0            0.0            0.0            0.0
   20            0.0            0.0            0.0            0.0            0.0
   21            0.0            0.0            0.0            0.0            0.0
   22            0.0            0.0            0.0            0.0            0.0
   23            0.0             1.000         0.0            0.0            0.0
   24            0.0             1.000         0.0            0.0            0.0
   25            0.0            0.0             1.000         0.0            0.0
   26            0.0            0.0             1.000         0.0            0.0
   27            0.0            0.0            0.0             1.000         0.0
   28            0.0            0.0            0.0             1.000         0.0
   29            0.0            0.0            0.0            0.0             1.000
   30            0.0            0.0            0.0            0.0             1.000
NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING    PROBLEM    1584
CPU TIME USED      0.568 SECONDS
```

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PAGE  10  BMDP

BMDP2R - STEPWISE REGRESSION
MAR 11, 1985         AT 20:58:43
PROGRAM CONTROL INFORMATION

NO MORE CONTROL LANGUAGE.
PROGRAM TERMINATED
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12. APPENDIX VI

The Computer Program In Fortran, Input Data Table And Output Of Results For Back Calculated Yield Of Slurry Components And Other Experimental Results From The Model Parameters

The Computer Program In Fortran

```
C
C     BACK CALCULATION TO TEST
C     THE "GOODNESS OF FIT" OF
C     THE MODEL PARAMETERS
C
      DIMENSION OOREC(30,5),OAREC(30,5),OWREC(30,5),OYLD(30,5),
     1          OASH(30,5),OSOL(30,5),PHI(30,5),
     1          TIME(5),FA(30),FW(30),POREC(30,5),PAREC(30,5),
     1          PWREC(30,5),ORES(30,5),ARES(30,5),WRES(30,5),
     1          OORES(30,5),AARES(30,5),WWRES(30,5),
     1          TYLD(30,5),ASH(30,5),YLD(30,5),SOL(30,5),
     1          YRES(30,5),ASRES(30,5),WSRES(30,5)
      REAL  KF(30,5),KS(30,5),ARSS,ORSS,WRSS,O,A,W,OO,AA,WW,
     1      AARSS,OORSS,WWRSS
      INTEGER IX(30,5)
      DATA TIME/0.5,1.0,2.0,4.0,8.0/,FA/11.93,11.73,11.90,11.98,
     1    11.79,11.87,12.06,11.96,11.99,12.05,11.87,12.10,11.88,11.82,
     1    11.92,11.98,11.94,11.46,11.91,11.95,11.92,11.30,12.04,11.89,
     1    11.93,11.87,11.67,11.76,11.92,11.85/,FW/3.0,3.0,3.0,3.0,3.0,
     1   3.0,3.0,3.0,6.0,6.0,6.0,6.0,6.0,6.0,6.0,6.0,4.5,4.5,4.5,4.5,
     1    4.5,4.5,4.5,4.5,4.5,4.5,4.5,4.5,3.0,6.0/
C
C     READ THE INPUT DATA
C
      READ(5,10) ((IX(I,J), J=1,4), I=1,30)
   10 FORMAT(4I2)
      READ(5,11) ((OOREC(I,J), J=1,5), I=1,30)
      READ(5,11) ((OAREC(I,J), J=1,5), I=1,30)
      READ(5,11) ((OWREC(I,J), J=1,5), I=1,30)
      READ(5,11) ((OYLD(I,J), J=1,5), I=1,30)
      READ(5,11) ((OASH(I,J), J=1,5), I=1,30)
      READ(5,11) ((OSOL(I,J), J=1,5), I=1,30)
   11 FORMAT(5F10.1)
C
C     BACK CALCULATION OF PHI, KF, AND KS FROM THE
C     RESULTS OF S.L.R. OF PARAMETERS USING BMDP
C
      DO 100 I=1,30
      PHI(I,1)=34.1249-14.2086*IX(I,4)-11.3767*IX(I,3)-8.3122*IX(I,1)
     1    +14.0002*(IX(I,1)**2)+4.3150*IX(I,3)*IX(I,4)-6.7197*(IX(I,4)
     1    **2)
      KF(I,1)=1.6189-0.3089*IX(I,4)-0.2050*(IX(I,4)**2)
      KS(I,1)=0.0574-0.0177*IX(I,4)*IX(I,1)-0.0123*IX(I,1)*IX(I,3)*IX
     1    (I,4)-0.0355*(IX(I,4)**2)+0.0246*(IX(I,1)**2)
      PHI(I,2)=64.9991-10.0055*IX(I,4)-8.0194*IX(I,3)-6.3061*IX(I,1)+
     1  5.1688*(IX(I,1)**2)
      KF(I,2)=1.4599-0.2946*IX(I,4)-0.1130*IX(I,3)-0.1827*(IX(I,4)**2)
      KS(I,2)=0.0137-0.0041*IX(I,1)*IX(I,4)-0.0030*IX(I,1)*IX(I,3)*IX
     1  (I,4)
      PHI(I,3)=92.7865-3.3772*IX(I,4)-1.3044*IX(I,1)-1.0661*IX(I,3)-
     1    1.1050*
     1    IX(I,1)*IX(I,4)+0.8469*IX(I,2)+0.6787*IX(I,1)*IX(I,2)*IX(I,4)+
     1    0.5125*IX(I,1)*IX(I,2)+1.7206*(IX(I,1)**2)-1.3644*(IX(I,3)**2)
      KF(I,3)=1.3813-0.2064*IX(I,1)*IX(I,4)-0.1825*IX(I,3)*IX(I,4)-
     1    0.1285*IX(I,4)+0.1235*IX(I,1)*IX(I,2)*IX(I,4)
      KS(I,3)=0.0086-0.0012*IX(I,3)*IX(I,4)+0.0011*IX(I,2)*IX(I,4)-
     1    0.0011*IX(I,1)*IX(I,3)*IX(I,4)
  100 CONTINUE
C
C     BACK CALCULATION OF RECOVERIES FOR ORGANIC, ASH, AND WATER
C
      DO 200 I=1,30
      DO 300 J=1,5
      POREC(I,J)=(100.0-PHI(I,1))*(1.0-EXP(-KF(I,1)*TIME(J)))+
     1  PHI(I,1)*(1.0-EXP(-KS(I,1)*TIME(J)))
      PAREC(I,J)=(100.0-PHI(I,2))*(1.0-EXP(-KF(I,2)*TIME(J)))+
     1  PHI(I,2)*(1.0-EXP(-KS(I,2)*TIME(J)))
      PWREC(I,J)=(100.0-PHI(I,3))*(1.0-EXP(-KF(I,3)*TIME(J)))+
     1  PHI(I,3)*(1.0-EXP(-KS(I,3)*TIME(J)))
  300 CONTINUE
  200 CONTINUE
C
C     BACK CALCULATION OF CUM. RECOVERIES, CUM. WT. % ASH, AND CUM. WT. %
C     SOLIDS AT EACH TIME INCREMENT
C
      DO 400 I=1,30
      DO 500 J=1,5
      YLD(I,J)=(FA(I)*PAREC(I,J)+(100.0-FA(I))*POREC(I,J))/100.00
      ASH(I,J)=((FA(I)*PAREC(I,J))/YLD(I,J))
      TYLD(I,J)=(FW(I)*YLD(I,J))+((100.0-FW(I))*PWREC(I,J))
      SOL(I,J)=(((FW(I)*YLD(I,J))/TYLD(I,J)))*100.0
  500 CONTINUE
  400 CONTINUE
C
C     OUTPUT OF RESULTS
C
      WRITE(6,1000)
 1000 FORMAT('1',20X,31('*')/' ',20X,'*',2X,'BACK CALCULATION TO TEST'
     1,3X,'*'/' ',20X,'*',4X,'"GOODNESS OF FIT" OF',5X,'*'/' ',20X,
     1'*',4X,'THE MODEL PARAMETERS',5X,'*'/21X,31('*'))
      DO 2000 I=1,30
      WRITE(6,1010) I
 1010 FORMAT('-','IDENTIFICATION:  ',5X,'TEST #  ',I2,23X,'TYPE:
     1MODELLING TESTS'/' ',18('-'))
      WRITE(6,1020)
 1020 FORMAT('0','SLURRY COMPONENT RECOVERIES:  '/' ',27('-')/' ',
     1 'FLOAT',6X,'ORGANICS',23X,'ASH',27X,'WATER'/' ','TIME(MIN.)
     1'/' ',95('-'))
      WRITE(6,1030)
 1030 FORMAT(' ',10X,'OBS',7X,'PRED',7X,'RES',6X,'OBS',7X,'PRED',5X,
     1'RES',7X,'OBS',7X,'PRED',5X,'RES')
      WRITE(6,1031)
 1031 FORMAT(' ',95('-'))
      DO 2010 J=1,5
      ORES(I,J)=OOREC(I,J)-POREC(I,J)
      ARES(I,J)=OAREC(I,J)-PAREC(I,J)
      WRES(I,J)=OWREC(I,J)-PWREC(I,J)
 2010 CONTINUE
      ORSS=0.0
      ARSS=0.0
      WRSS=0.0
      DO 2020 K=1,5
      ORSS=ORSS+ORES(I,K)**2
      ARSS=ARSS+ARES(I,K)**2
      WRSS=WRSS+WRES(I,K)**2
 2020 CONTINUE
      DO 2021 J=1,5
      WRITE(6,1040) TIME(J),OOREC(I,J),POREC(I,J),ORES(I,J),OAREC(I,J),
     1              PAREC(I,J),ARES(I,J),OWREC(I,J),PWREC(I,J),WRES(I,J)
 1040 FORMAT(' ',10(F6.2,5X))
 2021 CONTINUE
      WRITE(6,1050)
 1050 FORMAT(' ',95('-'))
      WRITE(6,1060) ORSS,ARSS,WRSS
 1060 FORMAT(' ',28X,F7.2,23X,F7.2,23X,F7.2)
      WRITE(6,1061)
 1061 FORMAT(' ',95('-'))
      WRITE(6,1070)
 1070 FORMAT('O','EXPERIMENTAL RESULTS:  '/' ',21('-')/' ',
     1 '  FLOAT',6X,'CUM',28X,'CUM',25X,'CUM'/' ','TIME(MIN.)',1X,
     1 'RECOVERED',22X,'WT. %',23X,'WT. %'/' ',10X,'% SOLIDS',
     1 24X,'ASH',25X,'% SOLIDS'/' ',95('-'))
      WRITE(6,1071)
 1071 FORMAT(' ',10X,'OBS',7X,'PRED',7X,'RES',6X,'OBS',7X,'PRED',5X,
     1'RES',7X,'OBS',7X,'PRED',6X,'RES')
      WRITE(6,1072)
 1072 FORMAT(' ',95('-'))
      DO 2030 J=1,5
      YRES(I,J)=OYLD(I,J)-YLD(I,J)
      ASRES(I,J)=OASH(I,J)-ASH(I,J)
      WSRES(I,J)=OSOL(I,J)-SOL(I,J)
 2030 CONTINUE
      OORSS=0.0
      AARSS=0.0
      WWRSS=0.0
      DO 2040 K=1,5
      OORSS=OORSS+YRES(I,K)**2
      AARSS=AARSS+ASRES(I,K)**2
      WWRSS=WWRSS+WSRES(I,K)**2
 2040 CONTINUE
      DO 2041 J=1,5
      WRITE(6,1080) TIME(J),OYLD(I,J),YLD(I,J),YRES(I,J),OASH(I,J),
     1              ASH(I,J),ASRES(I,J),OSOL(I,J),SOL(I,J),WSRES(I,J)
 1080 FORMAT(' ',10(F8.2,5X))
 2041 CONTINUE
      WRITE(6,1090)
 1090 FORMAT(' ',95('-'))
      WRITE(6,1100) OORSS,AARSS,WWRSS
 1100 FORMAT(' ',28X,F7.2,23X,F7.2,23X,F7.2)
      WRITE(6,1110)
 1110 FORMAT(' ',95('-'))
 2000 CONTINUE
      STOP
      END
End of file
```

Input Data Table

```
  1      -1-1-1-1
  2       1-1-1-1
  3      -1 1-1-1
  4       1 1-1-1
  5      -1-1 1-1
  6       1-1 1-1
  7      -1 1 1-1
  8       1 1 1-1
  9      -1-1-1 1
 10       1-1-1 1
 11      -1 1-1 1
 12       1 1-1 1
 13      -1-1 1 1
 14       1-1 1 1
 15      -1 1 1 1
 16       1 1 1 1
 17       0 0 0 0
 18       0 0 0 0
 19       0 0 0 0
 20       0 0 0 0
 21       0 0 0 0
 22       0 0 0 0
 23      -1 0 0 0
 24       1 0 0 0
 25       0-1 0 0
 26       0 1 0 0
 27       0 0-1 0
 28       0 0 1 0
 29       0 0 0-1
 30       0 0 0 1
 31      11.89,16.09,22.99,27.62,34.59,
 32      22.95,31.96,39.13,46.66,51.14,
 33      12.57,17.85,22.80,28.50,36.20,
 34      30.67,38.17,46.77,52.80,57.97,
 35      27.21,43.88,53.78,62.01,67.47,
 36      40.77,56.25,66.74,75.42,80.84,
 37      30.97,43.58,54.12,62.84,68.88,
 38      39.50,53.29,67.73,78.98,82.71,
 39      24.98,42.85,53.20,61.34,68.03,
 40      34.87,53.81,68.88,75.74,78.13,
 41      26.16,46.70,57.81,68.80,73.58,
 42      31.83,52.77,71.12,79.41,83.04,
 43      26.21,47.38,63.22,75.08,82.44,
 44      28.78,61.72,79.99,84.39,91.10,
 45      28.38,49.70,63.56,72.64,83.45,
 46      31.53,59.56,80.34,88.23,91.01,
 47      31.88,62.74,81.90,70.24,78.57,
 48      29.65,62.57,63.29,71.22,78.44,
 49      31.99,63.28,63.16,72.65,80.12,
 50      38.38,53.16,61.72,89.80,76.27,
 51      36.58,64.55,65.48,72.34,76.78,
 52      33.91,57.08,66.58,75.27,80.28,
 53      30.44,49.26,57.62,85.88,72.88,
 54      35.40,50.05,56.29,70.77,78.88,
 55      37.12,59.04,68.34,74.16,77.63,
 56      35.16,51.38,63.55,72.38,77.70,
 57      31.27,46.78,55.47,63.83,68.10,
 58      46.62,70.83,63.13,88.45,90.40,
 59      36.38,46.54,58.13,66.85,71.03,
 60      31.79,68.12,80.44,87.70,90.01,


 61       4.38, 7.00, 8.82,10.62,13.83,
 62       8.89,12.45,15.33,18.08,21.01,
 63       5.10, 7.40, 9.52,11.88,15.18,
 64      11.78,14.90,19.73,23.32,26.46,
 65      11.81,19.14,23.86,28.03,31.48,
 66      19.47,29.08,35.36,39.86,44.34,
 67      13.82,19.55,24.52,28.94,32.63,
 68      20.34,27.94,36.41,43.42,46.90,
 69      11.07,19.07,23.96,27.87,31.18,
 70      17.37,27.42,35.48,41.08,43.87,
 71      12.69,22.75,28.31,33.48,37.89,
 72      16.55,24.25,38.93,44.48,48.01,
 73      12.13,22.11,30.25,37.54,42.05,
 74      15.18,27.33,45.95,52.70,56.24,
 75      14.34,25.33,33.12,38.78,45.78,
 76      16.50,31.80,46.31,52.94,55.32,
 77      15.06,25.12,29.84,34.42,38.07,
 78      14.08,25.12,30.78,35.01,37.78,
 79      16.17,25.58,30.99,36.83,41.00,
 80      18.10,25.33,29.84,34.22,37.57,
 81      17.25,26.08,31.82,35.88,38.39,
 82      16.83,28.44,33.68,39.13,42.38,
 83      13.79,22.38,28.78,31.10,34.88,
 84      17.37,25.12,28.68,37.27,41.78,
 85      17.15,28.55,34.11,38.11,41.32,
 86      16.84,28.13,31.78,36.82,38.88,
 87      14.01,21.23,28.53,29.77,32.38,
 88      25.78,41.19,51.33,56.80,59.36,
 89      15.98,21.82,26.22,30.80,33.88,
 90      17.83,32.97,46.28,53.58,58.05,
 91       1.53, 2.55, 3.87, 5.93, 8.78,
 92       1.94, 2.08, 4.19, 5.71, 8.06,
 93       1.26, 2.38, 3.64, 5.80, 9.30,
 94       1.40, 2.47, 4.03, 5.58, 8.44,
 95       2.37, 3.81, 5.38, 7.13,10.47,
 96       3.30, 4.88, 6.70, 8.62,12.77,
 97       2.83, 3.95, 5.44, 7.20,10.49,
 98       3.13, 4.53, 6.15, 8.00,11.54,
 99       4.27, 7.08, 8.95,11.16,14.02,
100       5.85, 9.43,12.72,16.89,19.72,
101       3.47, 5.80, 7.17, 9.42,12.79,
102       4.47, 7.19, 9.98,12.42,15.89,
103       4.35, 7.22, 9.24,11.16,13.77,
104       4.45, 7.23,11.23,13.63,17.28,
105       4.86, 8.01,10.09,12.12,15.95,
106       4.54, 8.12,11.59,13.85,16.85,
107       3.80, 5.95, 7.73,10.08,12.88,
108       3.22, 5.56, 7.35, 9.18,11.58,
109       3.94, 5.33, 8.10,10.42,13.29,
110       4.44, 6.10, 7.96,10.12,13.06,
111       4.04, 6.20, 7.49, 9.67,11.86,
112       3.73, 6.19, 7.78, 9.93,12.30,
113       3.32, 5.16, 6.57, 8.88,12.08,
114       4.38, 6.28, 7.78,10.80,13.10,
115       4.05, 6.71, 8.97,11.53,15.55,
116       3.78, 5.91, 8.04,10.37,13.09,
117       3.58, 5.80, 7.51, 9.84,12.55,
118       4.70, 7.45,10.98,14.78,18.39,
119       2.85, 4.02, 5.81, 7.64,11.10,
120       4.64, 7.79,11.16,13.10,16.28,
121     11.01,18.75,21.28,25.88,32.05,
122     21.30,25.66,34.34,42.36,47.61,
123     11.88,16.51,21.22,28.52,33.58,
124     26.41,35.39,43.54,49.28,54.20,
125     25.44,40.64,50.34,58.10,63.33,
126     28.25,54.60,64.80,71.20,76.53,
127     28.82,40.71,50.86,58.67,81.37,
128     37.24,50.30,64.03,74.78,78.49,
129     23.33,40.04,48.74,57.37,63.85,
130     22.76,50.88,63.12,71.60,74.92,
131     24.86,43.68,84.13,82.94,89.32,
132     30.00,48.63,67.26,76.22,78.84,
133     24.83,44.37,59.33,70.62,77.83,
134     27.30,48.67,76.02,84.23,87.04,
135     26.59,48.80,55.94,88.61,78.87,
136     29.76,99.29,78.33,84.07,88.92,
137     28.89,45.46,86.13,88.01,73.02,
138     27.82,49.36,59.49,88.98,71.81,
139     30.01,50.00,88.37,88.39,76.82,
140     25.86,48.67,57.84,85.59,71.88,
141     34.31,51.26,61.52,88.03,72.28,
142     21.95,53.84,62.88,71.18,75.88,
143     28.47,48.08,63.98,81.88,88.15,
144     33.24,47.06,62.98,88.76,74.24,
145     24.75,55.42,64.28,59.86,73.23,
146     33.04,48.32,89.84,88.19,73.29,
147     28.26,43.78,81.88,59.86,84.83,
148     44.17,67.17,78.39,84.71,88.78,
149     33.92,45.29,84.29,82.50,88.85,
150     30.18,55.20,78.69,83.72,88.06,
151       5.03,  5.08,  5.01,  5.02,  5.14,
152       4.89,  4.91,  4.94,  5.00,  5.17,
153       5.19,  5.28,  5.33,  5.32,  5.36,
154       4.95,  5.03,  5.42,  5.66,  5.84,
155       5.34,  5.38,  5.46,  5.55,  5.72,
156       6.01,  6.28,  6.44,  6.54,  6.84,
157       5.71,  5.74,  5.80,  5.88,  6.06,
158       6.45,  6.55,  6.71,  6.85,  7.08,
159       5.62,  5.64,  5.70,  5.75,  5.80,
160       6.33,  6.46,  6.71,  6.85,  6.93,
161       6.13,  6.15,  6.20,  6.21,  6.45,
162       6.61,  6.80,  6.94,  7.06,  7.30,
163       5.88,  5.93,  6.12,  6.32,  6.44,
164       6.80,  6.52,  7.05,  7.20,  7.84,
165       6.38,  6.43,  6.57,  6.71,  6.89,
166       6.54,  6.86,  7.15,  7.43,  7.84,
167       5.86,  5.98,  6.06,  6.15,  6.24,
168       5.91,  5.95,  6.05,  6.11,  6.15,
169       5.96,  6.03,  6.15,  6.29,  6.40,
170       5.95,  6.01,  6.10,  6.14,  6.21,
171       5.90,  5.98,  6.07,  6.15,  6.24,
172       5.85,  5.98,  6.10,  6.22,  6.31,
173       5.74,  5.78,  5.88,  5.89,  6.03,
174       6.26,  6.30,  6.48,  6.60,  6.74,
175       5.85,  6.12,  6.30,  6.47,  6.70,
176       5.99,  6.07,  6.15,  6.27,  6.38,
177       5.57,  5.65,  5.72,  5.78,  5.82,
178       6.85,  7.30,  7.59,  7.84,  8.03,
179       5.68,  5.75,  5.82,  5.84,  6.13,
180       6.92,  6.95,  7.33,  7.45,  7.88,



181     19.27,17.80,15.11,12.59,10.65,
182     26.80,24.16,22.24,19.65,15.06,
183     24.09,20.03,16.58,13.89,11.00,
184     40.95,33.65,26.64,23.13,17.86,
185     24.71,24.70,22.28,19.80,15.82,
186     24.84,23.94,21.62,19.05,14.98,
187     24.65,23.78,22.08,19.94,15.78,
188     26.63,25.23,24.02,22.13,17.12,
189     25.84,26.57,26.20,24.66,22.47,
190     22.15,20.63,16.39,17.37,15.70,
191     28.13,26.61,28.46,26.95,23.06,
192     25.06,26.72,28.17,24.15,19.65,
193     26.01,27.66,26.57,26.26,26.00,
194     24.15,25.04,26.07,24.35,20.78,
195     26.71,26.91,27.25,26.31,23.70,
196     25.02,26.11,25.13,23.85,20.73,
197     26.99,27.02,25.06,22.57,19.83,
198     27.47,26.61,26.76,24.76,21.83,
199     26.78,27.50,26.02,23.95,21.42,
200     27.74,27.84,25.66,23.61,20.65,
201     27.30,26.78,25.64,23.72,21.22,
202     27.22,27.64,26.06,23.67,21.23,
203     28.31,30.18,28.44,25.59,21.44,
204     26.17,26.00,24.13,22.72,20.93,
205     25.23,24.51,22.15,19.23,15.61,
206     27.99,26.54,24.74,22.51,19.83,
207     27.61,26.64,24.24,21.95,18.27,
208     25.07,25.29,21.38,17.74,15.06,
209     27.76,25.30,22.84,19.35,15.29,
210     28.45,27.15,26.80,26.17,21.78,
End of File
```

Output Of Results

```
                  ********************************
                  *   BACK CALCULATION TO TEST   *
                  *     "GOODNESS OF FIT" OF     *
                  *     THE MODEL PARAMETERS     *
                  ********************************

IDENTIFICATION:      . TEST #   1                    TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                          ASH                             WATER
TIME(MIN.)
---------------------------------------------------------------------------------------------
         OBS       PRED        RES         OBS        PRED      RES        OBS       PRED      RES
---------------------------------------------------------------------------------------------
 0.50     11.89     13.39      -1.50       4.58       3.75      0.83       1.53      1.70     -0.17
 1.00     18.09     19.95      -1.86       7.00       5.69      1.31       2.55      2.93     -0.38
 2.00     22.99     26.00      -3.01       8.82       7.67      1.15       3.97      4.60     -0.63
 4.00     27.63     32.41      -4.78      10.62      10.14      0.48       5.93      6.81     -0.88
 8.00     34.59     42.65      -8.06      13.63      14.56     -0.93       8.76     10.38     -1.62
---------------------------------------------------------------------------------------------
                             102.51                             4.83                          3.97
---------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                               CUM                          CUM
TIME(MIN.) RECOVERED                         WT. %                        WT. %
           % SOLIDS                          ASH                          % SOLIDS
---------------------------------------------------------------------------------------------
         OBS       PRED        RES         OBS        PRED      RES        OBS       PRED      RES
---------------------------------------------------------------------------------------------
 0.50     11.01     12.24      -1.23       5.03       3.66      1.37      19.27     18.20      1.07
 1.00     16.75     18.24      -1.49       5.05       3.72      1.33      17.90     16.16      1.74
 2.00     21.28     23.82      -2.54       5.01       3.84      1.17      15.11     13.79      1.32
 4.00     25.58     29.75      -4.17       5.02       4.07      0.95      12.65     11.81      0.84
 8.00     32.05     39.30      -7.25       5.14       4.42      0.72      10.85     10.48      0.37
---------------------------------------------------------------------------------------------
                              80.09                             6.45                          6.46
---------------------------------------------------------------------------------------------

IDENTIFICATION:        TEST #   2                    TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                          ASH                             WATER
TIME(MIN.)
---------------------------------------------------------------------------------------------
         OBS       PRED        RES         OBS        PRED      RES        OBS       PRED      RES
---------------------------------------------------------------------------------------------
 0.50     22.95     22.99      -0.04       8.89      10.99     -2.10       1.94      2.19     -0.25
 1.00     31.96     33.59      -1.63      12.45      16.02     -3.57       3.08      3.36     -0.28
 2.00     39.13     42.03      -2.90      15.33      19.90     -4.57       4.19      4.59     -0.40
 4.00     45.58     48.76      -3.18      18.08      22.80     -4.72       5.71      6.11     -0.40
 8.00     51.14     58.38      -7.24      21.01      27.26     -6.25       8.66      8.65      0.01
---------------------------------------------------------------------------------------------




                              73.57                            99.48                          0.46
---------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                               CUM                          CUM
TIME(MIN.) RECOVERED                         WT. %                        WT. %
           % SOLIDS                          ASH                          % SOLIDS
---------------------------------------------------------------------------------------------
         OBS       PRED        RES         OBS        PRED      RES        OBS       PRED      RES
---------------------------------------------------------------------------------------------
 0.50     21.30     21.58      -0.28       4.89       5.98     -1.09      25.60     22.34      3.26
 1.00     29.68     31.53      -1.85       4.91       5.96     -1.05      24.16     22.48      1.68
 2.00     36.34     39.43      -3.09       4.94       5.82     -0.88      22.28     20.99      1.29
 4.00     42.36     45.71      -3.35       5.00       5.85     -0.85      19.69     18.79      0.90
 8.00     47.61     54.73      -7.12       5.17       5.84     -0.67      15.08     16.05     -0.97
---------------------------------------------------------------------------------------------
                              74.98                             4.42                         16.84
---------------------------------------------------------------------------------------------

IDENTIFICATION:        TEST #   3                    TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                          ASH                             WATER
TIME(MIN.)
---------------------------------------------------------------------------------------------
         OBS       PRED        RES         OBS        PRED      RES        OBS       PRED      RES
---------------------------------------------------------------------------------------------
 0.50     12.57     13.39      -0.82       5.10       3.75      1.35       1.26      0.91      0.35
 1.00     17.85     19.95      -2.10       7.40       5.69      1.71       2.26      1.67      0.59
 2.00     22.80     26.00      -3.20       9.52       7.67      1.85       3.64      2.55      1.09
 4.00     28.50     32.41      -3.91      11.88      10.14      1.74       5.60      4.07      1.53
 8.00     36.20     42.65      -6.45      15.16      14.56      0.60       9.30      6.88      2.42
---------------------------------------------------------------------------------------------
                              72.18                            11.55                          9.86
---------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                               CUM                          CUM
TIME(MIN.) RECOVERED                         WT. %                        WT. %
           % SOLIDS                          ASH                          % SOLIDS
---------------------------------------------------------------------------------------------
         OBS       PRED        RES         OBS        PRED      RES        OBS       PRED      RES
---------------------------------------------------------------------------------------------
 0.50     11.68     12.24      -0.56       5.19       3.65      1.54      24.09     29.[illegible]     -5.27
 1.00     16.61     18.25      -1.64       5.29       3.71      1.58      20.03     26.[illegible]     -6.39
 2.00     21.22     23.82      -2.60       5.33       3.83      1.50      16.56     22.45     -5.89
 4.00     26.52     29.76      -3.24       5.32       4.06      1.26      13.89     18.43     -4.54
 8.00     33.69     39.31      -5.62       5.35       4.41      0.94      11.00     15.02     -4.02
---------------------------------------------------------------------------------------------
                              51.79                             9.62                        140.13
---------------------------------------------------------------------------------------------

IDENTIFICATION:        TEST #   4                    TYPE:        MODELLING TESTS
---------------
```

```
SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                                 ASH                                  WATER
TIME(MIN.)
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES
-------------------------------------------------------------------------------------------------------------
 0.50      30.67      22.99        7.68       11.76        10.99       0.77         1.40        1.22       0.18
 1.00      38.17      33.59        4.58       14.90        16.02      -1.12         2.47        1.95       0.52
 2.00      46.77      42.03        4.74       19.73        19.90      -0.17         4.03        2.82       1.21
 4.00      52.80      48.76        4.04       23.32        22.80       0.52         5.59        3.94       1.65
 8.00      57.97      58.38       -0.41       26.46        27.26      -0.80         8.44        5.93       2.51
-------------------------------------------------------------------------------------------------------------
                                 118.98                                2.79                               10.79
-------------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                      CUM                                 CUM
TIME(MIN.) RECOVERED                                 WT. %                               WT. %
           % SOLIDS                                  ASH                                 % SOLIDS
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES
-------------------------------------------------------------------------------------------------------------
 0.50      28.41      21.55        6.86        4.95         6.11      -1.16        40.95       35.39       5.56
 1.00      35.39      31.48        3.91        5.03         6.10      -1.07        32.85       33.26      -0.41
 2.00      43.54      39.38        4.16        5.42         6.06      -0.64        26.64       30.14      -3.50
 4.00      49.28      45.65        3.63        5.66         5.98      -0.32        23.13       26.37      -3.24
 8.00      54.20      54.65       -0.45        5.84         5.98      -0.14        17.98       22.19      -4.21
-------------------------------------------------------------------------------------------------------------
                                  93.00                                3.02                               71.60
-------------------------------------------------------------------------------------------------------------

IDENTIFICATION:        TEST #   5                          TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                                 ASH                                  WATER
TIME(MIN.)
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES
-------------------------------------------------------------------------------------------------------------
 0.50      27.21      30.30       -3.09       11.81        11.52       0.29         2.37        3.07      -0.70
 1.00      43.66      43.32        0.34       19.14        17.15       1.99         3.61        4.67      -1.06
 2.00      53.78      51.68        2.10       23.86        21.45       2.41         5.38        6.83      -1.45
 4.00      62.01      54.78        7.23       28.03        23.53       4.50         7.13        8.97      -1.84
 8.00      67.47      57.70        9.77       31.48        25.58       5.90        10.47       12.50      -2.03
-------------------------------------------------------------------------------------------------------------
                                 161.87                               64.97                               11.22
-------------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                      CUM                                 CUM
TIME(MIN.) RECOVERED                                 WT. %                               WT. %
           % SOLIDS                                  ASH                                 % SOLIDS
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES



-------------------------------------------------------------------------------------------------------------
 0.50      25.44      28.08       -2.64        5.34         4.83       0.51        24.71       22.05       2.66
 1.00      40.84      40.23        0.61        5.39         5.03       0.36        24.70       20.35       4.35
 2.00      50.34      48.11        2.23        5.45         5.26       0.19        22.28       17.90       4.38
 4.00      58.10      51.09        7.01        5.55         5.43       0.12        19.86       14.87       4.99
 8.00      63.33      53.91        9.42        5.72         5.59       0.13        15.62       11.77       3.85
-------------------------------------------------------------------------------------------------------------
                                 150.13                                0.46                               84.89
-------------------------------------------------------------------------------------------------------------

IDENTIFICATION:        TEST #   6                          TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                                 ASH                                  WATER
TIME(MIN.)
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES
-------------------------------------------------------------------------------------------------------------
 0.50      40.77      40.69        0.08       19.47        18.53       0.94         3.30        3.99      -0.69
 1.00      58.25      58.52       -0.27       29.08        27.73       1.35         4.96        5.82      -0.86
 2.00      68.74      70.59       -1.85       35.36        35.06       0.30         6.70        7.57      -0.87
 4.00      75.42      76.65       -1.23       39.66        39.32       0.34         8.62        9.86      -1.24
 8.00      80.84      82.85       -2.01       44.34        44.25       0.09        12.77       14.09      -1.32
-------------------------------------------------------------------------------------------------------------
                                   9.42                                2.93                                5.23
-------------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                      CUM                                 CUM
TIME(MIN.) RECOVERED                                 WT. %                               WT. %
           % SOLIDS                                  ASH                                 % SOLIDS
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES
-------------------------------------------------------------------------------------------------------------
 0.50      38.25      38.04        0.21        6.01         5.83       0.18        24.84       22.77       2.07
 1.00      54.80      54.83       -0.03        6.26         6.05       0.21        23.94       22.58       1.36
 2.00      64.60      66.43       -1.83        6.44         6.32       0.12        21.62       21.35       0.27
 4.00      71.20      72.18       -0.98        6.58         6.52       0.06        19.05       18.46       0.59
 8.00      76.53      78.23       -1.70        6.84         6.77       0.07        14.59       14.66      -0.07
-------------------------------------------------------------------------------------------------------------
                                   6.53                                0.10                                6.56
-------------------------------------------------------------------------------------------------------------

IDENTIFICATION:        TEST #   7                          TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                                 ASH                                  WATER
TIME(MIN.)
-------------------------------------------------------------------------------------------------------------
            OBS        PRED        RES         OBS          PRED       RES          OBS         PRED       RES
-------------------------------------------------------------------------------------------------------------
 0.50      30.97      30.30        0.67       13.82        11.52       2.30         2.69        2.19       0.50
 1.00      43.58      43.32        0.26       19.55        17.15       2.40         3.98        3.38       0.60
 2.00      54.12      51.68       2.44      24.52      21.45       3.07       5.44       4.65       0.79
 4.00      62.94      54.78       8.16      28.94      23.53       5.41       7.20       6.22       0.98
 8.00      68.68      57.70      10.98      32.63      25.58       7.05      10.49       9.03       1.46
........................................................................................................
                                193.72                            89.53                            4.32
........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                CUM                             CUM
TIME(MIN.) RECOVERED                           WT. %                           WT. %
           % SOLIDS                            ASH                             % SOLIDS
........................................................................................................
           OBS        PRED        RES        OBS        PRED       RES        OBS        PRED       RES
........................................................................................................
 0.50      28.92      28.03       0.89       5.71       4.96       0.75      24.65      28.40      -3.75
 1.00      40.71      40.16       0.55       5.74       5.15       0.59      23.76      26.89      -3.13
 2.00      50.58      48.03       2.55       5.80       5.39       0.41      22.08      24.22      -2.14
 4.00      58.87      51.01       7.86       5.88       5.56       0.32      19.94      20.23      -0.29
 8.00      61.37      53.82       7.55       6.06       5.73       0.33      15.75      15.56       0.19
........................................................................................................
                                126.32                             1.30                           28.55
........................................................................................................

IDENTIFICATION:       TEST #   8                      TYPE:        MODELLING TESTS
...............

SLURRY COMPONENT RECOVERIES:
............................
FLOAT       ORGANICS                           ASH                              WATER
TIME(MIN.)
........................................................................................................
           OBS        PRED        RES        OBS        PRED       RES        OBS        PRED       RES
........................................................................................................
 0.50      39.50      40.69      -1.19      20.34      18.53       1.81       3.13       2.83       0.30
 1.00      53.29      58.52      -5.23      27.94      27.73       0.21       4.53       4.29       0.24
 2.00      67.73      70.69      -2.96      36.41      35.06       1.35       6.15       5.80       0.35
 4.00      78.98      76.65       2.33      43.42      39.32       4.10       8.00       7.75       0.25
 8.00      82.71      82.85      -0.14      46.90      44.25       2.65      11.54      11.30       0.24
........................................................................................................
                                 42.99                            28.99                            0.39
........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                CUM                             CUM
TIME(MIN.) RECOVERED                           WT. %                           WT. %
           % SOLIDS                            ASH                             % SOLIDS
........................................................................................................
           OBS        PRED        RES        OBS        PRED       RES        OBS        PRED       RES
........................................................................................................
 0.50      37.24      38.04      -0.80       6.45       5.83       0.62      26.53      29.33      -2.80
 1.00      50.30      54.83      -4.53       6.55       6.05       0.50      25.23      28.34      -3.11
 2.00      64.03      66.43      -2.40       6.71       6.31       0.40      24.02      26.15      -2.13
 4.00      74.79      72.18       2.61       6.85       6.51       0.34      22.13      22.37      -0.24
 8.00      78.49      78.23       0.26       7.05       6.76       0.29      17.12      17.64      -0.52
........................................................................................................
                                 33.84                             0.99                           22.39
........................................................................................................


IDENTIFICATION:       TEST #   9                      TYPE:        MODELLING TESTS
...............

SLURRY COMPONENT RECOVERIES:
............................
FLOAT       ORGANICS                           ASH                              WATER
TIME(MIN.)
........................................................................................................
           OBS        PRED        RES        OBS        PRED       RES        OBS        PRED       RES
........................................................................................................
 0.50      24.96      25.46      -0.50      11.07      11.46      -0.39       4.27       4.08       0.19
 1.00      42.85      40.57       2.28      19.07      18.25       0.82       7.06       5.99       1.07
 2.00      53.20      55.33      -2.13      23.96      24.95      -0.99       8.95       7.63       1.32
 4.00      61.34      64.71      -3.37      27.87      29.50      -1.63      11.18       9.21       1.97
 8.00      68.03      71.86      -3.83      31.16      33.83      -2.67      14.02      11.94       2.08
........................................................................................................
                                 35.96                            11.58                           11.13
........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                CUM                             CUM
TIME(MIN.) RECOVERED                           WT. %                           WT. %
           % SOLIDS                            ASH                             % SOLIDS
........................................................................................................
           OBS        PRED        RES        OBS        PRED       RES        OBS        PRED       RES
........................................................................................................
 0.50      23.33      23.80      -0.47       5.62       5.77      -0.15      25.84      27.15      -1.31
 1.00      40.04      37.90       2.14       5.64       5.77      -0.13      26.57      28.75      -2.18
 2.00      49.74      51.59      -1.85       5.70       5.78      -0.08      26.20      30.19      -3.99
 4.00      57.37      60.49      -3.12       5.75       5.85      -0.10      24.68      29.53      -4.85
 8.00      63.66      67.30      -3.64       5.80       6.03      -0.23      22.47      26.46      -3.99
........................................................................................................
                                 31.57                             0.11                           61.89
........................................................................................................

IDENTIFICATION:       TEST #  10                      TYPE:        MODELLING TESTS
...............

SLURRY COMPONENT RECOVERIES:
............................
FLOAT       ORGANICS                           ASH                              WATER
TIME(MIN.)
........................................................................................................
           OBS        PRED        RES        OBS        PRED       RES        OBS        PRED       RES
........................................................................................................
 0.50      34.87      31.98       2.89      17.37      16.69       0.68       5.65       6.09      -0.44
 1.00      53.81      50.59       3.22      27.42      26.41       1.01       9.43       9.81      -0.38
 2.00      66.88      67.99      -1.11      35.46      35.57      -0.11      13.72      13.71       0.01
 4.00      75.74      77.09      -1.35      41.08      40.73       0.35      16.69      16.75      -0.06
 8.00      79.13      81.30      -2.17      43.87      44.05      -0.18      19.72      20.13      -0.41
........................................................................................................
                                 26.44                             1.66                            0.51
........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                CUM                             CUM
TIME(MIN.) RECOVERED                           WT. %                           WT. %
```

```
            % SOLIDS                                  ASH                                      % SOLIDS
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES
...........................................................................................................
  0.50      32.78        30.14         2.64         5.33         5.68       -0.35        22.15        24.02       -1.87
  1.00      50.66        47.67         2.99         5.46         5.68       -0.22        20.83        23.67       -2.84
  2.00      63.12        64.08        -0.96         5.71         5.69        0.02        18.39        22.98       -4.59
  4.00      71.60        72.70        -1.10         5.85         5.76        0.09        17.37        21.69       -4.32
  8.00      74.92        76.81        -1.89         5.99         5.92        0.07        15.70        19.59       -3.89
...........................................................................................................
                                      21.58                                 0.18                                66.35
...........................................................................................................

IDENTIFICATION:        TEST #  11                          TYPE:          MODELLING TESTS
...............

SLURRY COMPONENT RECOVERIES:
...........................
FLOAT       ORGANICS                                  ASH                                       WATER
TIME(MIN.)
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES
...........................................................................................................
  0.50      26.16        25.48         0.68        12.69        11.46        1.23         3.47         4.18       -0.71
  1.00      45.70        40.57         5.13        22.75        18.25        4.50         5.60         6.40       -0.80
  2.00      57.61        55.33         2.28        28.31        24.95        3.36         7.17         8.54       -1.37
  4.00      66.90        64.71         2.19        33.46        29.50        3.96         9.42        10.65       -1.23
  8.00      73.58        71.86         1.72        37.69        33.83        3.86        12.79        14.11       -1.32
...........................................................................................................
                                      50.94                                63.70                                 6.01
...........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                       CUM                                      CUM
TIME(MIN.) RECOVERED                                  WT. %                                    WT. %
            % SOLIDS                                  ASH                                      % SOLIDS
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES
...........................................................................................................
  0.50      24.56        23.82         0.74         6.13         5.71        0.42        28.13        26.66        1.47
  1.00      43.86        37.92         5.94         6.15         5.71        0.44        29.51        27.43        2.08
  2.00      54.13        51.72         2.41         6.20         5.72        0.48        29.48        27.87        1.61
  4.00      62.94        60.53         2.41         6.31         5.79        0.52        26.99        26.61        0.38
  8.00      69.32        67.35         1.97         6.45         5.96        0.49        23.08        23.36       -0.28
...........................................................................................................
                                      51.28                                 1.11                                 9.26
...........................................................................................................

IDENTIFICATION:        TEST #  12                          TYPE:          MODELLING TESTS
...............

SLURRY COMPONENT RECOVERIES:
...........................
FLOAT       ORGANICS                                  ASH                                       WATER
TIME(MIN.)
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES




...........................................................................................................
  0.50      31.83        31.98        -0.15        16.55        16.69       -0.14         4.47         5.16       -0.69
  1.00      52.77        50.59         2.18        28.25        26.41        1.84         7.19         8.08       -0.89
  2.00      71.12        67.99         3.13        38.93        35.57        3.36         9.98        11.01       -1.03
  4.00      79.41        77.09         2.32        44.45        40.73        3.72        12.42        13.73       -1.31
  8.00      83.04        81.30         1.74        48.01        44.05        3.96        16.95        17.82       -0.87
...........................................................................................................
                                      23.01                                44.20                                 4.77
...........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                       CUM                                      CUM
TIME(MIN.) RECOVERED                                  WT. %                                    WT. %
            % SOLIDS                                  ASH                                      % SOLIDS
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES
...........................................................................................................
  0.50      30.00        30.13        -0.13         6.61         6.70       -0.09        26.06        27.17       -1.11
  1.00      49.83        47.67         2.16         6.80         6.70        0.10        26.72        27.37       -0.65
  2.00      67.26        64.06         3.20         6.94         6.72        0.22        26.17        27.09       -0.92
  4.00      75.22        72.69         2.53         7.06         6.76        0.30        24.15        25.26       -1.11
  8.00      78.84        76.79         2.05         7.30         6.94        0.36        19.65        21.57       -1.92
...........................................................................................................
                                      25.52                                 0.29                                 7.43
...........................................................................................................

IDENTIFICATION:        TEST #  13                          TYPE:          MODELLING TESTS
...............

SLURRY COMPONENT RECOVERIES:
...........................
FLOAT       ORGANICS                                  ASH                                       WATER
TIME(MIN.)
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES
...........................................................................................................
  0.50      26.21        31.46        -5.25        12.13        15.52       -3.39         4.35         4.58       -0.23
  1.00      47.38        49.97        -2.59        22.11        25.69       -3.58         7.22         7.05        0.17
  2.00      63.22        67.75        -4.53        30.25        36.92       -6.67         9.24         9.34       -0.10
  4.00      75.09        78.18        -3.09        37.54        45.04       -7.50        11.16        11.18       -0.02
  8.00      82.44        84.55        -2.11        42.05        50.48       -8.43        13.77        13.81       -0.04
...........................................................................................................
                                      68.79                               196.03                                 0.08
...........................................................................................................

EXPERIMENTAL RESULTS:
.....................
 FLOAT      CUM                                       CUM                                      CUM
TIME(MIN.) RECOVERED                                  WT. %                                    WT. %
            % SOLIDS                                  ASH                                      % SOLIDS
...........................................................................................................
             OBS          PRED          RES          OBS          PRED        RES          OBS          PRED        RES
...........................................................................................................
  0.50      24.53        29.57        -5.04         5.88         6.24       -0.36        26.01        29.19       -3.18
  1.00      44.37        47.08        -2.71         5.93         6.48       -0.55        27.68        29.88       -2.20
  2.00      59.33        64.09        -4.76         6.12         6.84       -0.72        28.57        30.46       -1.89
  4.00      70.62        74.25        -3.63         6.32         7.21       -0.89        28.28        29.77       -1.49
  8.00      77.63        80.50        -2.87         6.44         7.45       -1.01        26.00        27.12       -1.12
```

```
--------------------------------------------------------------------------------------------------------
                                    76.75                          2.76                            22.02
--------------------------------------------------------------------------------------------------------

IDENTIFICATION:       TEST #  14                         TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                            ASH                                 WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------------
            OBS       PRED       RES         OBS        PRED      RES         OBS        PRED       RES
--------------------------------------------------------------------------------------------------------
 0.50      28.78     37.55      -8.77       15.16      19.60     -4.44        4.45       4.93      -0.48
 1.00      51.72     59.19      -7.47       27.33      32.21     -4.88        7.23       8.45      -1.22
 2.00      79.89     78.80       1.09       45.95      45.62      0.33       11.23      12.82      -1.59
 4.00      88.39     87.87       0.52       52.70      53.82     -1.12       13.63      16.57      -2.94
 8.00      91.10     89.62       1.48       56.24      56.48     -0.24       17.26      19.13      -1.87
--------------------------------------------------------------------------------------------------------
                               136.42                         44.97                            16.34
--------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                CUM                                CUM
TIME(MIN.) RECOVERED                           WT. %                              WT. %
           % SOLIDS                            ASH                                % SOLIDS
--------------------------------------------------------------------------------------------------------
            OBS       PRED       RES         OBS        PRED      RES         OBS        PRED       RES
--------------------------------------------------------------------------------------------------------
 0.50      27.20     35.43      -8.23        6.50       6.54     -0.04       24.15      31.46      -7.31
 1.00      48.87     56.00      -7.13        6.52       6.80     -0.28       26.04      29.74      -3.70
 2.00      76.02     74.97       1.05        7.05       7.19     -0.14       26.07      27.18      -1.11
 4.00      84.23     83.84       0.39        7.30       7.59     -0.29       24.35      24.42      -0.07
 8.00      87.04     85.70       1.34        7.54       7.79     -0.25       20.79      22.24      -1.45
--------------------------------------------------------------------------------------------------------
                               121.66                          0.24                            70.38
--------------------------------------------------------------------------------------------------------

IDENTIFICATION:       TEST #  15                         TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                            ASH                                 WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------------
            OBS       PRED       RES         OBS        PRED      RES         OBS        PRED       RES
--------------------------------------------------------------------------------------------------------
 0.50      28.36     31.46      -3.10       14.34      15.52     -1.18        4.88       4.40       0.48
 1.00      49.70     49.97      -0.27       25.33      25.69     -0.36        8.01       7.10       0.91
 2.00      63.56     67.75      -4.19       33.12      36.92     -3.80       10.09       9.98       0.11
 4.00      72.64     78.18      -5.54       38.76      45.04     -6.28       12.12      12.55      -0.43
 8.00      83.45     84.55      -1.10       45.78      50.48     -4.70       15.95      15.94       0.01
--------------------------------------------------------------------------------------------------------
                                59.17                         77.44                             1.24
--------------------------------------------------------------------------------------------------------



EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                CUM                                CUM
TIME(MIN.) RECOVERED                           WT. %                              WT. %
           % SOLIDS                            ASH                                % SOLIDS
--------------------------------------------------------------------------------------------------------
            OBS       PRED       RES         OBS        PRED      RES         OBS        PRED       RES
--------------------------------------------------------------------------------------------------------
 0.50      26.69     29.56      -2.87        6.38       6.26      0.12       25.71      30.00      -4.29
 1.00      46.80     47.07      -0.27        6.43       6.50     -0.07       26.91      29.74      -2.83
 2.00      59.94     64.07      -4.13        6.57       6.87     -0.30       27.25      29.06      -1.81
 4.00      68.61     74.23      -5.62        6.71       7.23     -0.52       26.31      27.41      -1.10
 8.00      78.97     80.49      -1.52        6.89       7.48     -0.59       23.79      24.37      -0.58
--------------------------------------------------------------------------------------------------------
                                59.32                          0.72                            31.28
--------------------------------------------------------------------------------------------------------

IDENTIFICATION:       TEST #  16                         TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                            ASH                                 WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------------
            OBS       PRED       RES         OBS        PRED      RES         OBS        PRED       RES
--------------------------------------------------------------------------------------------------------
 0.50      31.53     37.55      -6.02       16.50      19.60     -3.10        4.54       4.77      -0.23
 1.00      59.56     59.19       0.37       31.80      32.21     -0.41        8.12       7.84       0.28
 2.00      80.34     78.90       1.44       46.31      45.62      0.69       11.59      11.25       0.34
 4.00      88.23     87.87       0.36       52.94      53.82     -0.88       13.65      13.99      -0.34
 8.00      91.01     89.62       1.39       56.32      56.48     -0.16       16.95      16.74       0.21
--------------------------------------------------------------------------------------------------------
                                40.53                         11.04                             0.41
--------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                CUM                                CUM
TIME(MIN.) RECOVERED                           WT. %                              WT. %
           % SOLIDS                            ASH                                % SOLIDS
--------------------------------------------------------------------------------------------------------
            OBS       PRED       RES         OBS        PRED      RES         OBS        PRED       RES
--------------------------------------------------------------------------------------------------------
 0.50      29.76     35.40      -5.64        6.54       6.63     -0.09       25.02      32.16      -7.14
 1.00      56.29     55.96       0.33        6.66       6.90     -0.24       26.11      31.30      -5.19
 2.00      76.33     74.92       1.41        7.15       7.30     -0.15       25.13      29.83      -4.70
 4.00      84.07     83.79       0.28        7.43       7.69     -0.26       23.89      27.65      -3.76
 8.00      86.92     85.65       1.27        7.64       7.90     -0.26       20.72      24.62      -3.90
--------------------------------------------------------------------------------------------------------
                                35.63                          0.22                           129.38
--------------------------------------------------------------------------------------------------------

IDENTIFICATION:       CNTR #   1                         TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
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```
FLOAT      ORGANICS                         ASH                                  WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      31.88      37.53      -5.65      15.06      18.58      -3.52       3.60       3.94      -0.34
 1.00      52.74      54.74      -2.00      25.12      27.76      -2.64       5.95       6.14      -0.19
 2.00      61.90      67.00      -5.10      29.94      34.87      -4.93       7.73       8.31      -0.58
 4.00      70.24      72.77      -2.53      34.42      38.37      -3.95      10.08      10.32      -0.24
 8.00      76.57      78.44      -1.87      38.07      41.75      -3.68      12.88      13.38      -0.50
--------------------------------------------------------------------------------------------------
                                 71.88                            72.71                             0.80
--------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                              CUM                                  CUM
TIME(MIN.) RECOVERED                        WT. %                                WT. %
           % SOLIDS                         ASH                                  % SOLIDS
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      29.89      35.27      -5.38       5.86       6.20      -0.34      26.99      29.66      -2.67
 1.00      49.48      51.52      -2.04       5.99       6.43      -0.44      27.02      28.33      -1.31
 2.00      58.13      63.16      -5.03       6.08       6.59      -0.51      25.08      26.36      -1.28
 4.00      66.01      68.67      -2.66       6.15       6.67      -0.52      22.57      23.87      -1.30
 8.00      72.02      74.06      -2.04       6.24       6.73      -0.49      19.93      20.68      -0.75
--------------------------------------------------------------------------------------------------
                                 69.82                             1.09                            12.77
--------------------------------------------------------------------------------------------------

IDENTIFICATION:      CNTR #   2                       TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                         ASH                                  WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      29.65      37.53      -7.88      14.06      18.58      -4.52       3.32       3.94      -0.62
 1.00      52.57      54.74      -2.17      25.12      27.76      -2.64       5.56       6.14      -0.58
 2.00      63.29      67.00      -3.71      30.76      34.87      -4.11       7.35       8.31      -0.96
 4.00      71.22      72.77      -1.55      35.01      38.37      -3.36       9.18      10.32      -1.14
 8.00      76.44      78.44      -2.00      37.79      41.75      -3.96      11.56      13.38      -1.82
--------------------------------------------------------------------------------------------------
                                 87.02                            71.16                             6.27
--------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                              CUM                                  CUM
TIME(MIN.) RECOVERED                        WT. %                                WT. %
           % SOLIDS                         ASH                                  % SOLIDS
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      27.82      35.29      -7.47       5.91       6.24      -0.33      27.47      29.67      -2.20



 1.00      49.36      51.54      -2.18       5.95       6.39      -0.44      28.61      28.34       0.27
 2.00      59.45      63.15      -3.70       6.05       6.55      -0.50      26.76      26.37       0.39
 4.00      66.98      68.69      -1.71       6.11       6.62      -0.51      24.78      23.88       0.90
 8.00      71.91      74.08      -2.16       6.15       6.66      -0.52      21.93      20.69       1.24
--------------------------------------------------------------------------------------------------
                                 81.83                             1.10                             7.41
--------------------------------------------------------------------------------------------------

IDENTIFICATION:      CNTR #   3                       TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                         ASH                                  WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      31.99      37.53      -5.54      15.17      18.58      -3.41       3.94       3.94      -0.00
 1.00      53.26      54.74      -1.48      25.59      27.76      -2.17       6.33       6.14       0.19
 2.00      63.16      67.00      -3.84      30.99      34.87      -3.88       8.10       8.31      -0.21
 4.00      72.65      72.77      -0.12      36.53      38.37      -1.84      10.42      10.32       0.10
 8.00      80.12      78.44       1.68      41.00      41.75      -0.75      13.29      13.38      -0.09
--------------------------------------------------------------------------------------------------
                                 50.46                            35.27                             0.10
--------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                              CUM                                  CUM
TIME(MIN.) RECOVERED                        WT. %                                WT. %
           % SOLIDS                         ASH                                  % SOLIDS
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      30.01      35.28      -5.27       5.96       6.27      -0.31      26.78      29.66      -2.88
 1.00      50.00      51.53      -1.53       6.03       6.42      -0.39      27.50      28.34      -0.84
 2.00      59.37      63.17      -3.80       6.15       6.57      -0.42      26.02      26.37      -0.35
 4.00      68.39      68.68      -0.29       6.29       6.65      -0.36      23.95      23.87       0.08
 8.00      75.52      74.07       1.45       6.40       6.71      -0.31      21.42      20.69       0.73
--------------------------------------------------------------------------------------------------
                                 46.58                             0.65                             9.66
--------------------------------------------------------------------------------------------------

IDENTIFICATION:      CNTR #   4                       TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                         ASH                                  WATER
TIME(MIN.)
--------------------------------------------------------------------------------------------------
           OBS        PRED       RES        OBS        PRED       RES        OBS        PRED       RES
--------------------------------------------------------------------------------------------------
 0.50      38.36      37.53       0.83      18.10      18.58      -0.48       4.44       3.94       0.50
 1.00      53.18      54.74      -1.56      25.32      27.76      -2.44       6.10       6.14      -0.04
 2.00      61.72      67.00      -5.28      29.84      34.87      -5.03       7.96       8.31      -0.35
 4.00      69.80      72.77      -2.97      34.22      38.37      -4.15      10.12      10.32      -0.20
 8.00     76.27     78.44     -2.17     37.57     41.75     -4.18     13.06     13.38     -0.32
-----------------------------------------------------------------------------------------------
                              44.57                         66.10                          0.62
-----------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                                  CUM                          CUM
TIME(MIN.) RECOVERED                            WT. %                        WT. %
           % SOLIDS                             ASH                          % SOLIDS
-----------------------------------------------------------------------------------------------
           OBS       PRED       RES       OBS       PRED      RES       OBS       PRED      RES
-----------------------------------------------------------------------------------------------
 0.50     35.96     35.27      0.69      5.96      6.30     -0.34     27.76     29.66     -1.90
 1.00     49.87     51.51     -1.64      6.01      6.44     -0.43     27.94     28.33     -0.39
 2.00     57.94     63.15     -5.21      6.10      6.60     -0.50     25.66     26.36     -0.70
 4.00     65.59     68.66.    -3.07      6.18      6.68     -0.50     23.51     23.87     -0.36
 8.00     71.68     74.05     -2.37      6.21      6.74     -0.53     20.65     20.68     -0.03
-----------------------------------------------------------------------------------------------
                              45.41                          1.09                          4.38
-----------------------------------------------------------------------------------------------

IDENTIFICATION:       CNTR #   5                          TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
---------------------------
FLOAT      ORGANICS                             ASH                           WATER
TIME(MIN.)
-----------------------------------------------------------------------------------------------
           OBS       PRED       RES       OBS       PRED      RES       OBS       PRED      RES
-----------------------------------------------------------------------------------------------
 0.50     36.58     37.53     -0.95     17.25     18.58     -1.33      4.04      3.94      0.10
 1.00     54.59     54.74     -0.15     26.09     27.76     -1.67      6.20      6.14      0.06
 2.00     65.48     67.00     -1.52     31.82     34.87     -3.05      7.89      8.31     -0.42
 4.00     72.34     72.77     -0.43     35.65     38.37     -2.72      9.67     10.32     -0.65
 8.00     76.75     78.44     -1.69     38.39     41.75     -3.36     11.86     13.38     -1.52
-----------------------------------------------------------------------------------------------
                               6.28                         32.48                          2.93
-----------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                                  CUM                          CUM
TIME(MIN.) RECOVERED                            WT. %                        WT. %
           % SOLIDS                             ASH                          % SOLIDS
-----------------------------------------------------------------------------------------------
           OBS       PRED       RES       OBS       PRED      RES       OBS       PRED      RES
-----------------------------------------------------------------------------------------------
 0.50     34.31     35.27     -0.96      5.90      6.28     -0.38     27.30     29.66     -2.36
 1.00     51.25     51.52     -0.27      5.98      6.42     -0.44     26.78     28.34     -1.56
 2.00     61.52     63.17     -1.65      6.07      6.58     -0.51     25.64     26.37     -0.73
 4.00     66.03     66.67     -0.64      6.15      6.66     -0.51     23.72     23.87     -0.15
 8.00     72.25     74.07     -1.82      6.24      6.72     -0.48     21.22     20.68      0.54
-----------------------------------------------------------------------------------------------
                               7.43                          1.08                          8.84
-----------------------------------------------------------------------------------------------



IDENTIFICATION:       CNTR #   6                          TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
---------------------------
FLOAT      ORGANICS                             ASH                           WATER
TIME(MIN.)
-----------------------------------------------------------------------------------------------
           OBS       PRED       RES       OBS       PRED      RES       OBS       PRED      RES
-----------------------------------------------------------------------------------------------
 0.50     33.91     37.53     -3.62     16.63     18.58     -1.95      3.73      3.94     -0.21
 1.00     57.08     54.74      2.34     28.44     27.76      0.68      6.15      6.14      0.01
 2.00     66.58     67.00     -0.42     33.86     34.87     -1.01      7.78      8.31     -0.53
 4.00     75.27     72.77      2.50     39.13     38.37      0.76      9.93     10.32     -0.39
 8.00     80.28     78.44      1.84     42.36     41.75      0.61     12.30     13.38     -1.08
-----------------------------------------------------------------------------------------------
                              28.39                          6.24                          1.65
-----------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                                  CUM                          CUM
TIME(MIN.) RECOVERED                            WT. %                        WT. %
           % SOLIDS                             ASH                          % SOLIDS
-----------------------------------------------------------------------------------------------
           OBS       PRED       RES       OBS       PRED      RES       OBS       PRED      RES
-----------------------------------------------------------------------------------------------
 0.50     31.95     35.39     -3.44      5.89      5.93     -0.04     27.22     29.73     -2.51
 1.00     53.84     51.69      2.15      5.98      6.07     -0.09     27.64     28.40     -0.76
 2.00     62.88     63.37     -0.49      6.10      6.22     -0.12     26.08     26.43     -0.35
 4.00     71.18     68.89      2.29      6.22      6.29     -0.07     23.81     23.93     -0.12
 8.00     75.99     74.29      1.70      6.31      6.35     -0.04     21.23     20.74      0.49
-----------------------------------------------------------------------------------------------
                              24.84                          0.03                          7.27
-----------------------------------------------------------------------------------------------

IDENTIFICATION:       STR  #   1                          TYPE:       MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
---------------------------
FLOAT      ORGANICS                             ASH                           WATER
TIME(MIN.)
-----------------------------------------------------------------------------------------------
           OBS       PRED       RES       OBS       PRED      RES       OBS       PRED      RES
-----------------------------------------------------------------------------------------------
 0.50     30.44     26.45      3.99     13.79     12.71      1.08      3.32      2.47      0.85
 1.00     49.26     39.38      9.88     22.38     19.10      3.28      5.16      3.92      1.24
 2.00     57.62     50.38      7.24     26.75     24.33      2.42      6.57      5.54      1.03
 4.00     65.69     59.26      6.43     31.10     27.54      3.56      8.66      7.41      1.25
 8.00     72.66     70.69      1.97     34.66     31.47      3.19     12.08     10.56      1.52
-----------------------------------------------------------------------------------------------
                             211.16                         40.67                          7.19
-----------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                                  CUM                          CUM
TIME(MIN.) RECOVERED                            WT. %                        WT. %
```

```
           % SOLIDS                         ASH                           % SOLIDS
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES
----------------------------------------------------------------------------------------------------
 0.50     28.47      24.79       3.68       5.74       6.17     -0.43     29.31     32.12     -2.81
 1.00     46.08      36.94       9.14       5.76       6.23     -0.47     30.18     30.72     -0.54
 2.00     53.96      47.25       6.71       5.88       6.20     -0.32     28.44     28.66     -0.22
 4.00     61.58      55.44       6.14       5.99       5.98      0.01     25.59     26.07     -0.48
 8.00     68.15      65.97       2.18       6.03       5.74      0.29     21.44     22.74     -1.30
----------------------------------------------------------------------------------------------------
                               184.62                            0.59                          10.19
----------------------------------------------------------------------------------------------------

IDENTIFICATION:      STR  #   2                       TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                         ASH                            WATER
TIME(MIN.)
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES
----------------------------------------------------------------------------------------------------
 0.50     35.40      35.01       0.39      17.37      19.16     -1.79      4.38      3.74      0.64
 1.00     50.05      51.41      -1.36      25.12      28.62     -3.50      6.26      5.84      0.42
 2.00     56.29      63.84      -7.55      28.68      35.92     -7.24      7.78      7.93     -0.15
 4.00     70.77      71.22      -0.45      37.27      39.44     -2.17     10.60      9.92      0.68
 8.00     78.66      79.32      -0.66      41.76      42.77     -1.01     13.10     12.99      0.11
----------------------------------------------------------------------------------------------------
                                59.70                           73.51                           1.08
----------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                              CUM                          CUM
TIME(MIN.) RECOVERED                        WT. %                        WT. %
           % SOLIDS                         ASH                          % SOLIDS
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES
----------------------------------------------------------------------------------------------------
 0.50     33.24      33.11       0.13       6.26       6.94     -0.68     26.17     29.44     -3.27
 1.00     47.06      48.87      -1.81       6.39       7.05     -0.66     26.00     28.21     -2.21
 2.00     52.98      60.50      -7.52       6.48       7.12     -0.64     24.13     26.44     -2.31
 4.00     66.75      67.41      -0.66       6.69       7.02     -0.33     22.72     24.26     -1.54
 8.00     74.24      74.94      -0.70       6.74       6.84     -0.10     20.93     21.37     -0.44
----------------------------------------------------------------------------------------------------
                                60.03                            1.42                          23.49
----------------------------------------------------------------------------------------------------

IDENTIFICATION:      STR  #   3                       TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                         ASH                            WATER
TIME(MIN.)
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES



----------------------------------------------------------------------------------------------------
 0.50     37.12      37.53      -0.41      17.15      18.58     -1.43      4.05      4.35     -0.30
 1.00     59.04      54.74       4.30      28.55      27.76      0.79      5.71      5.76     -0.05
 2.00     68.34      67.00       1.34      34.11      34.87     -0.76      8.87      9.09     -0.22
 4.00     74.16      72.77       1.39      38.11      38.37     -0.26     11.53     11.14      0.39
 8.00     77.53      78.44      -0.91      41.32      41.75     -0.43     15.55     14.17      1.38
----------------------------------------------------------------------------------------------------
                                23.21                            3.49                           2.19
----------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                              CUM                          CUM
TIME(MIN.) RECOVERED                        WT. %                        WT. %
           % SOLIDS                         ASH                          % SOLIDS
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES
----------------------------------------------------------------------------------------------------
 0.50     34.75      35.27      -0.52       5.86       6.28     -0.42     25.23     27.62     -2.39
 1.00     55.42      51.52       3.90       6.12       6.43     -0.31     24.61     26.42     -1.81
 2.00     64.28      63.16       1.12       6.30       6.59     -0.29     22.16     24.67     -2.51
 4.00     69.88      68.67       1.21       6.47       6.67     -0.20     19.23     22.52     -3.29
 8.00     73.23      74.06      -0.83       6.70       6.72     -0.02     15.61     19.76     -4.15
----------------------------------------------------------------------------------------------------
                                18.88                            0.39                          43.84
----------------------------------------------------------------------------------------------------

IDENTIFICATION:      STR  #   4                       TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT      ORGANICS                         ASH                            WATER
TIME(MIN.)
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES
----------------------------------------------------------------------------------------------------
 0.50     35.16      37.53      -2.37      16.98      18.58     -1.60      3.76      3.53      0.23
 1.00     51.38      54.74      -3.36      25.13      27.76     -2.63      5.91      5.52      0.39
 2.00     63.55      67.00      -3.45      31.76      34.87     -3.11      8.04      7.53      0.51
 4.00     72.36      72.77      -0.41      36.62      38.37     -1.75     10.37      9.50      0.87
 8.00     77.70      78.44      -0.74      39.88      41.75     -1.87     13.09     12.59      0.50
----------------------------------------------------------------------------------------------------
                                29.62                           25.66                           1.47
----------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT     CUM                              CUM                          CUM
TIME(MIN.) RECOVERED                        WT. %                        WT. %
           % SOLIDS                         ASH                          % SOLIDS
----------------------------------------------------------------------------------------------------
           OBS        PRED        RES        OBS        PRED      RES       OBS       PRED      RES
----------------------------------------------------------------------------------------------------
 0.50     33.04      35.28      -2.24       5.99       6.25     -0.26     27.99     32.03     -4.04
 1.00     48.32      51.54      -3.22       6.07       6.39     -0.32     26.84     30.86     -4.02
 2.00     59.84      63.18      -3.34       6.19       6.55     -0.36     24.74     28.32     -3.58
 4.00     68.19      68.69      -0.50       6.27       6.63     -0.36     22.51     25.41     -2.90
 8.00     73.28      74.06      -0.78       6.35       6.69     -0.34     19.83     21.71     -1.88
```

```
------------------------------------------------------------------------------------------------------
                                27.44                              0.55                          57.23
------------------------------------------------------------------------------------------------------

IDENTIFICATION:       STR  #   5                             TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                             ASH                                WATER
TIME(MIN.)
------------------------------------------------------------------------------------------------------
            OBS        PRED        RES          OBS         PRED      RES         OBS         PRED       RES
------------------------------------------------------------------------------------------------------
 0.50       31.27      31.54      -0.27        14.01       15.19     -1.18        3.58        4.09      -0.51
 1.00       45.75      45.25       0.50        21.23       22.38     -1.15        5.60        6.36      -0.76
 2.00       55.47      57.30      -1.83        25.53       27.79     -2.26        7.51        8.59      -1.08
 4.00       63.83      63.75       0.08        29.77       30.83     -1.06        9.84       10.61      -0.77
 8.00       69.10      71.25      -2.15        32.39       34.56     -2.17       12.58       13.68      -1.10
------------------------------------------------------------------------------------------------------
                                 8.31                             13.67                           3.79
------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                  CUM                              CUM
TIME(MIN.) RECOVERED                             WT. %                            WT. %
            % SOLIDS                             ASH                              % SOLIDS
------------------------------------------------------------------------------------------------------
            OBS        PRED        RES          OBS         PRED      RES         OBS         PRED       RES
------------------------------------------------------------------------------------------------------
 0.50       29.26      29.63      -0.37         5.57        5.98     -0.41       27.41       25.47       1.94
 1.00       43.78      43.46       0.32         5.65        6.01     -0.36       26.54       24.36       2.18
 2.00       51.98      53.86      -1.88         5.72        6.02     -0.30       24.24       22.81       1.43
 4.00       59.86      59.91      -0.05         5.79        6.00     -0.21       21.95       21.02       0.93
 8.00       64.83      66.97      -2.14         5.82        6.02     -0.20       19.27       18.77       0.50
------------------------------------------------------------------------------------------------------
                                 8.34                              0.48                          11.67
------------------------------------------------------------------------------------------------------

IDENTIFICATION:       STR  #   6                             TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                             ASH                                WATER
TIME(MIN.)
------------------------------------------------------------------------------------------------------
            OBS        PRED        RES          OBS         PRED      RES         OBS         PRED       RES
------------------------------------------------------------------------------------------------------
 0.50       46.62      43.53       3.09        25.76       21.47      4.29        4.70        5.12      -0.42
 1.00       70.63      63.23       7.40        41.19       32.61      8.58        7.45        7.92      -0.47
 2.00       83.13      76.69       6.44        51.33       41.65      9.68       10.96       10.54       0.42
 4.00       88.45      81.80       6.65        56.60       45.86     10.74       14.75       12.66       2.09
 8.00       90.40      85.63       4.77        59.36       48.93     10.43       18.39       15.65       2.74
------------------------------------------------------------------------------------------------------
                               172.74                            409.72                          12.46
------------------------------------------------------------------------------------------------------



EXPERIMENTAL RESULTS
---------------------
 FLOAT      CUM                                  CUM                              CUM
TIME(MIN.) RECOVERED                             WT. %                            WT. %
            % SOLIDS                             ASH                              % SOLIDS
------------------------------------------------------------------------------------------------------
            OBS        PRED        RES          OBS         PRED      RES         OBS         PRED       RES
------------------------------------------------------------------------------------------------------
 0.50       44.17      40.93       3.24         6.85        6.18      0.67       26.07       27.34      -1.27
 1.00       67.17      59.62       7.55         7.20        6.44      0.76       25.29       26.18      -0.89
 2.00       79.39      72.56       6.83         7.59        6.76      0.83       21.39       24.50      -3.11
 4.00       84.71      77.57       7.14         7.84        6.97      0.87       17.74       22.41      -4.67
 8.00       86.75      81.31       5.44         8.03        7.09      0.94       15.05       19.66      -4.61
------------------------------------------------------------------------------------------------------
                               194.70                              3.36                          55.16
------------------------------------------------------------------------------------------------------

IDENTIFICATION:       STR  #   7                             TYPE:        MODELLING TESTS
---------------

SLURRY COMPONENT RECOVERIES:
----------------------------
FLOAT       ORGANICS                             ASH                                WATER
TIME(MIN.)
------------------------------------------------------------------------------------------------------
            OBS        PRED        RES          OBS         PRED      RES         OBS         PRED       RES
------------------------------------------------------------------------------------------------------
 0.50       36.38      34.18       2.20        15.98       14.23      1.75        2.66        2.42       0.24
 1.00       48.54      48.87      -0.33        21.62       20.93      0.69        4.03        3.80       0.23
 2.00       58.13      58.31      -0.18        26.22       25.99      0.23        5.61        5.28       0.33
 4.00       66.85      61.82       5.03        30.80       28.95      1.85        7.84        7.08       0.76
 8.00       71.03      65.08       5.95        33.86       32.78      1.08       11.10       10.23       0.87
------------------------------------------------------------------------------------------------------
                                65.75                              8.17                           1.56
------------------------------------------------------------------------------------------------------

EXPERIMENTAL RESULTS:
---------------------
 FLOAT      CUM                                  CUM                              CUM
TIME(MIN.) RECOVERED                             WT. %                            WT. %
            % SOLIDS                             ASH                              % SOLIDS
------------------------------------------------------------------------------------------------------
            OBS        PRED        RES          OBS         PRED      RES         OBS         PRED       RES
------------------------------------------------------------------------------------------------------
 0.50       33.92      31.80       2.12         5.68        5.33      0.35       27.76       28.91      -1.15
 1.00       45.29      45.54      -0.25         5.75        5.48      0.27       25.30       27.11      -1.81
 2.00       54.29      54.46      -0.17         5.82        5.69      0.13       22.54       24.19      -1.65
 4.00       62.50      57.90       4.60         5.94        5.96     -0.02       19.35       20.19      -0.84
 8.00       66.55      61.23       5.32         6.13        6.38     -0.25       15.29       15.62      -0.33
------------------------------------------------------------------------------------------------------
                                54.07                              0.28                           8.17
------------------------------------------------------------------------------------------------------

IDENTIFICATION:       STR  #   8                             TYPE:        MODELLING TESTS
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SLURRY COMPONENT RECOVERIES:
----------------------------
```

```
FLOAT        ORGANICS                            ASH                                   WATER
TIME(MIN.)
.........................................................................................................
             OBS        PRED        RES          OBS         PRED        RES          OBS         PRED        RES
.........................................................................................................
 0.50       31.79       37.02      -5.23        17.93        18.12      -0.19         4.64        5.23       -0.59
 1.00       56.13       56.37      -0.24        32.97        29.24       3.73         7.79        8.24       -0.45
 2.00       80.44       77.88       2.56        48.28        40.43       7.85        11.14       11.20       -0.06
 4.00       87.70       86.87       0.83        53.56        47.12       6.44        13.10       13.53       -0.43
 8.00       90.01       88.91       1.10        56.05        50.70       5.35        16.29       16.53       -0.24
.........................................................................................................
                                   35.90                               145.66                               0.80
.........................................................................................................

EXPERIMENTAL RESULTS:
......................
 FLOAT       CUM                                 CUM                                   CUM
TIME(MIN.)  RECOVERED                            WT. %                                 WT. %
            % SOLIDS                             ASH                                   % SOLIDS
.........................................................................................................
             OBS        PRED        RES          OBS         PRED        RES          OBS         PRED        RES
.........................................................................................................
 0.50       30.18       34.78      -4.60         6.92         6.17       0.75        25.49       29.80       -4.31
 1.00       55.20       54.91       0.29         6.95         6.31       0.64        27.15       29.85       -2.70
 2.00       76.69       73.43       3.26         7.33         6.53       0.80        26.60       29.51       -2.91
 4.00       83.72       82.16       1.56         7.45         6.80       0.65        25.17       27.93       -2.76
 8.00       86.06       84.38       1.68         7.58         7.12       0.46        21.76       24.57       -2.81
.........................................................................................................
                                   37.10                                 2.25                              49.84
.........................................................................................................
```